ERROR ESTIMATES AND QUALITY CONTROL WITH CANDIDATE VERSION 5.0

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AIRS Science Team Meeting

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OBJECTIVES

- Generate improved error estimates written out for "all" IR/MW parameters

  Now ready to do for Version 5

  Surface skin temperature

  T(p)

  q(p)

  $\hat{R}_i$

- Improve quality control using error estimates

- Define methodology to generate level 3 parameters

  Number and meaning of JPL quality flags do not change

  Good for data assimilation - JPL quality flag 0 (best)

  Good for Level 3 products - JPL quality flags 0 or 1 (good)

  Do not use - JPL quality flag 2

  Pressures that define upper, mid, and bottom temperature boundaries are now case dependent

GENERATION OF EMPIRICAL ERROR ESTIMATES $\delta X_i'$

This step is done after physical retrieval is otherwise completed

Methodology used for $\delta SST', \delta T(p)'$ is identical

Uses internally computed values

Currently uses values of 14 (or 15?) parameters Y_j

12 Y_j terms are used in Version 4 quality control

Also uses $\eta_{reg}^{(1)}$, qual wat, and possibly $\left(\hat{\Theta}_{2388} - \hat{\Theta}_{2387}\right)$

$\delta X_i'$, error estimate for X_i, is computed according to

$$\delta X_i' = \sum M_{ij} Y_j$$

Determination of M_{ij}

Use profiles with "truth"

$$\Delta X_i = \left| X_i - X_i^{TRUTH} \right|$$

Each profile now has $\Delta X_i, Y_j$

Solve for M_{ij} by regression - minimizes RMS $\left(\Delta X_i - \delta X_i'\right)$

Coefficients of M are system dependent

January 19 NetMeeting showed results using GSFC Version 4.7

Results shown today use GSFC Candidate Version 5.0 to generate and test M

Candidate Version 5.0 is similar to what is currently running at JPL

JPL Version similar to GSFC Version 4.7 but with new IR RTA and IR/MW tuning

Methodology will not change for Version 5.0

Only coefficients of M (101,15) may change

GENERATION OF COEFFICIENTS M

M_{ij} generated using all September 29, 2004 cases passing Stratospheric Temperature Test

Test is analogous to what is done in Version 4.0

IR/MW retrieval produced for these cases

MW only retrieval is produced otherwise

ECMWF taken as "truth" to provide ΔX_i

$\delta SST', \delta T(p)'$ used for quality control

M_{ij} tested on January 25, 2003

Assessment of quality control

Accuracy of $\delta X_i'$

Same basic approach is used for $\delta \hat{R}_i', \delta q(p)'$

Form of error estimate predictor is different

$\delta T(p)'$ used for quality control for $q(p), \hat{R}_i$

DIFFERENCES OF CANDIDATE VERSION 5.0 FROM CURRENT JPL VERSION

Differences candidate Version 5.0 was our attempt to make further improvement in current JPL system

Cloud clearing and cloud parameter retrieval channels

Different for "ocean" (non-frozen ocean), "land" (not non-frozen ocean)

"Ocean" - same as at JPL, but add three 15 μm channels

"Land" - use ocean channels, but only for frequencies < 741 cm^{-1} (namelist cutoff)

Temperature profile - same for ocean and land

Add 30 channels 2386 cm^{-1} - 2358 cm^{-1} (non-LTE)

Add 12 channels 2197 cm^{-1} - 2252 cm^{-1}

Temp2 channels

Add four 15 μm channels sensitive to water vapor, ozone

Add six water vapor sounding channels

Ozone retrieval - same channels for ocean and land

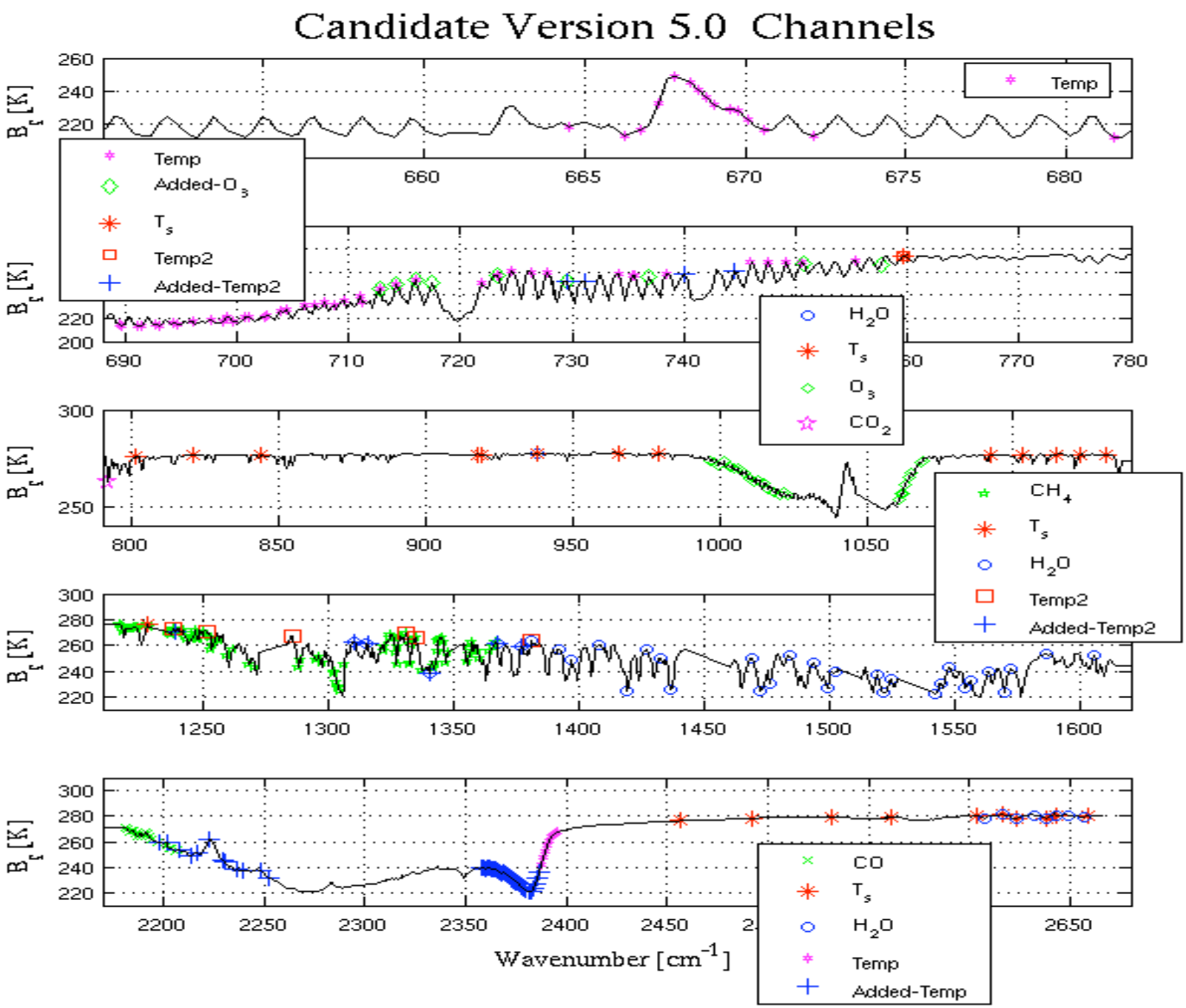
Add ten 15 μm channels sensitive to O_3 absorption

Many namelist changes added at once

System is currently suboptimal

Addition of cloud clearing channels may be the source of the problem

Need two weeks for further testing and optimization


Candidate Version 5.0 Channels
B_f [K]
Temp
Added-O_3
T_s
Temp2
Added-Temp2
H_2O
O_3
CO_2
CH_4
CO
Wavenumber [cm^-1]

METHODOLOGY USED FOR T(p) QUALITY FLAGS

Define a profile dependent pressure, p_g, above which the temperature profile is flagged as good

Use error estimate $\delta'T(p)$ to determine p_g

Start from 70 mb and set p_g to be the pressure at the first level below which

$\delta'T(p) >$ threshold for n (currently = 3) consecutive layers

Temperature profile statistics include errors of T(p) down to $p = p_g$

Threshold is currently a function of pressure

Different thresholds used for non-frozen ocean, not "non-frozen ocean" (called land)

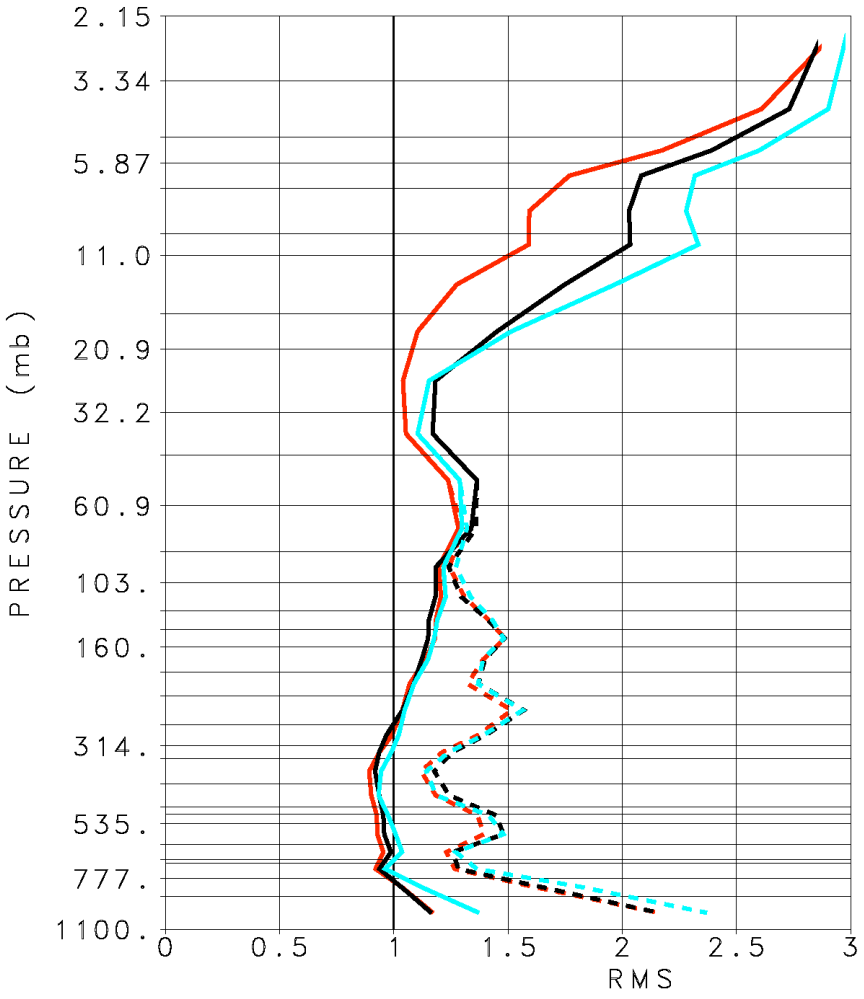
Threshold values currently specified at 70 mb, $p_{surf/2}$, p_{surf}

Threshold is linearly interpolated in log p between values

Current candidate Version 5.0 thresholds:

Pressure	Ocean	Land
70 mb	1.75K	1.75K
$p_{surf/2}$	1.25K	1.25K
p_{surf}	2.0K	2.5K

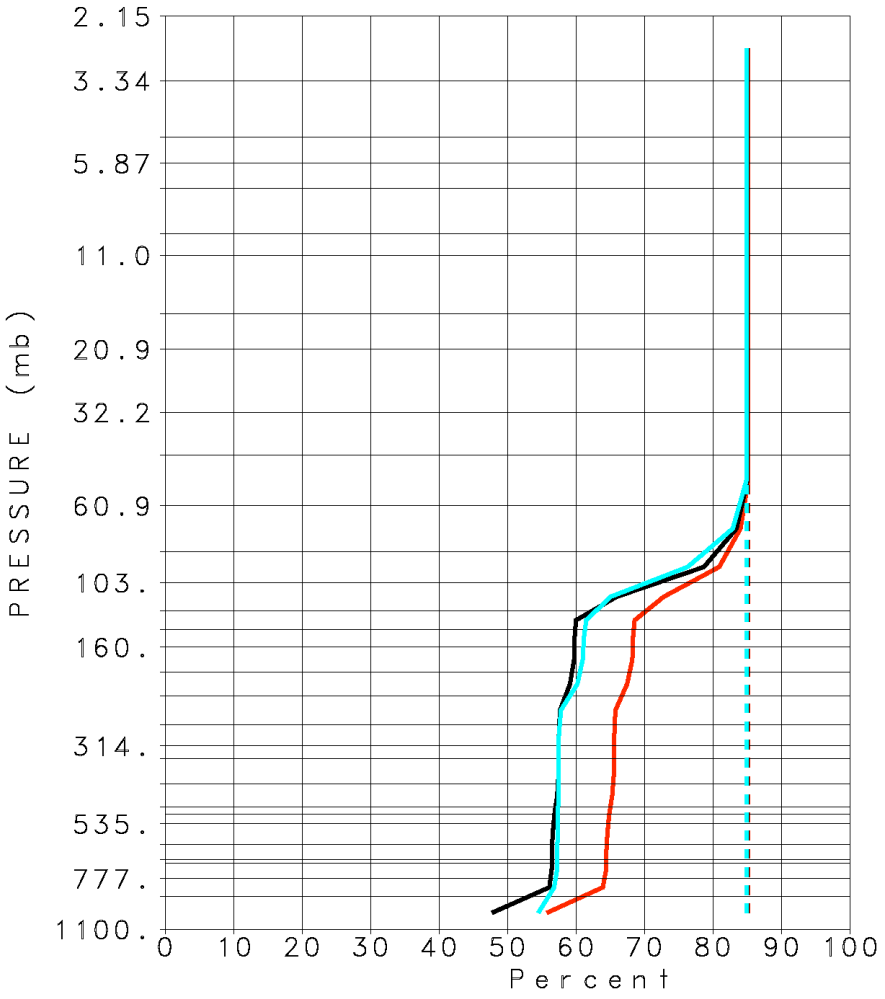
LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003
50N to 50S Ocean



V4.7
V4.7 Stratosphere Good Cases
V4.9 with v4.7 Error Estimate
V4.9 with v4.7 Error Estimate Strat Good Cases
Candidate v5.0
Candidate v5.0 Stratosphere Good Cases

Percent of IR/MW Cases Included

January 25, 2003
50N to 50S Ocean



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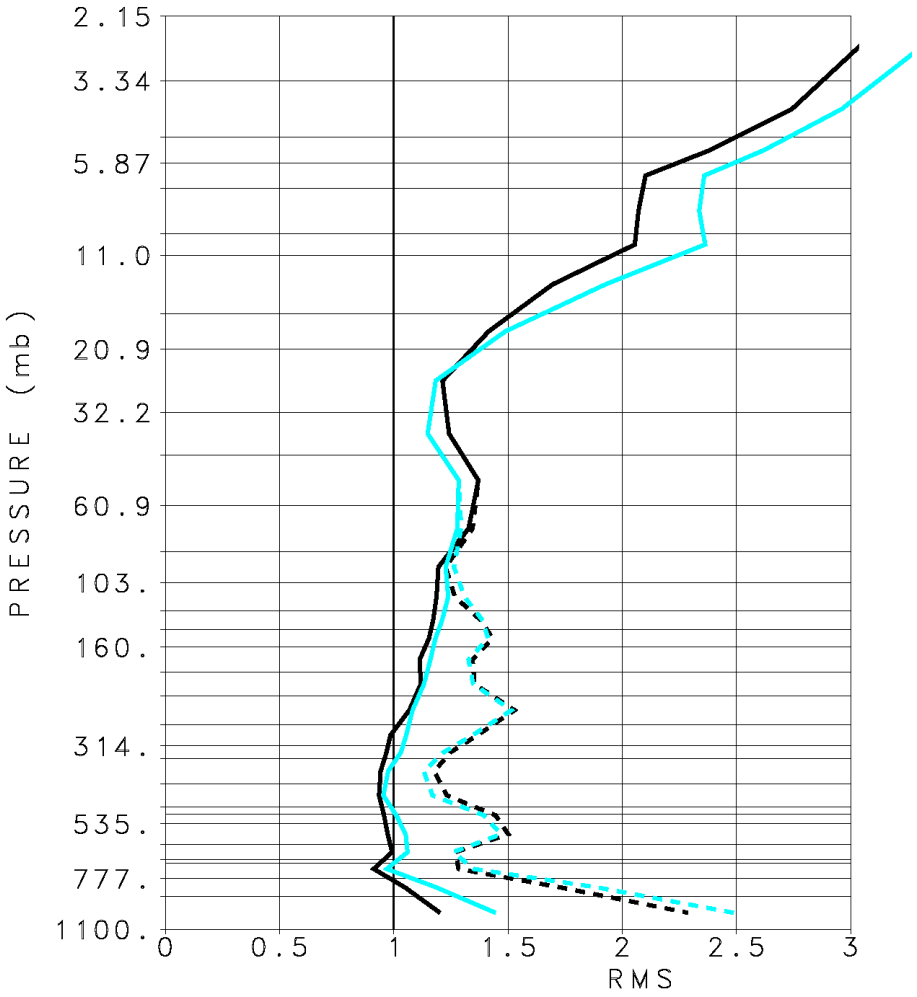
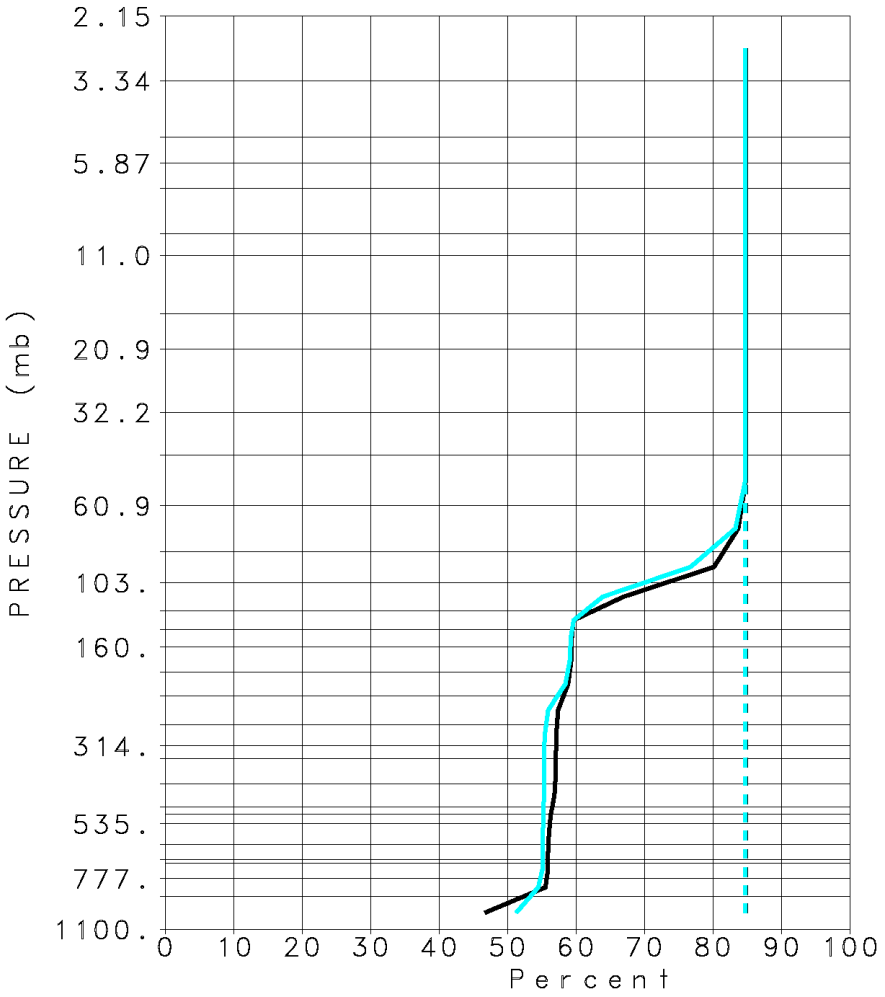
LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003 Nighttime Only
50N to 50S Ocean



V4.9 with v4.7 Error Estimate
V4.9 with v4.7 Error Estimate Strat Good Cases
Candidate v5.0
Candidate v5.0 Stratosphere Good Cases

Percent of IR/MW Cases Included

January 25, 2003 Nighttime Only
50N to 50S Ocean



V4.9 with v4.7 Error Estimate
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January 25, 2003 Daytime Only
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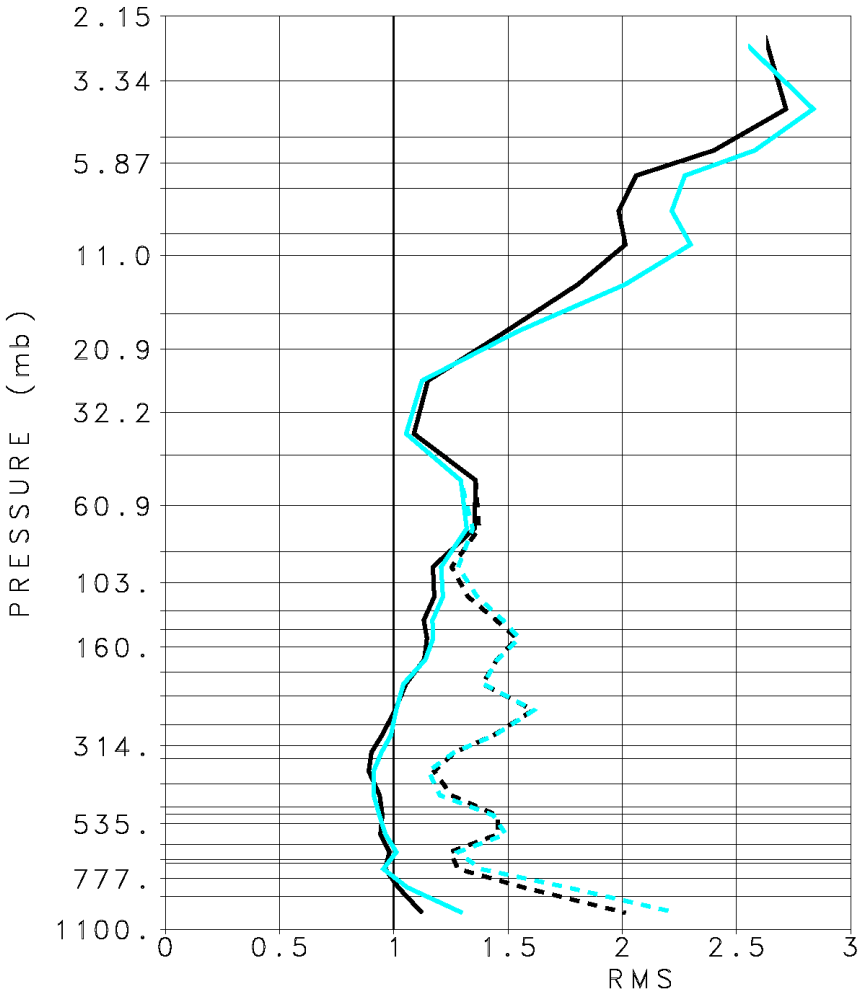

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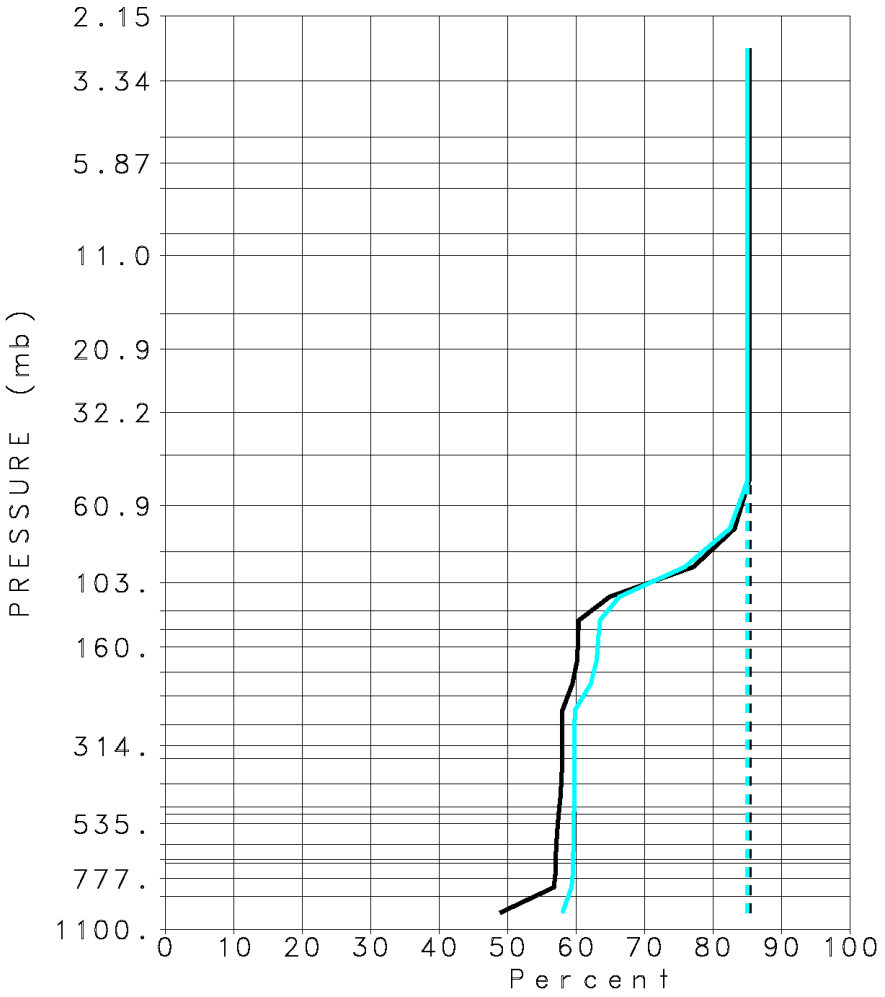

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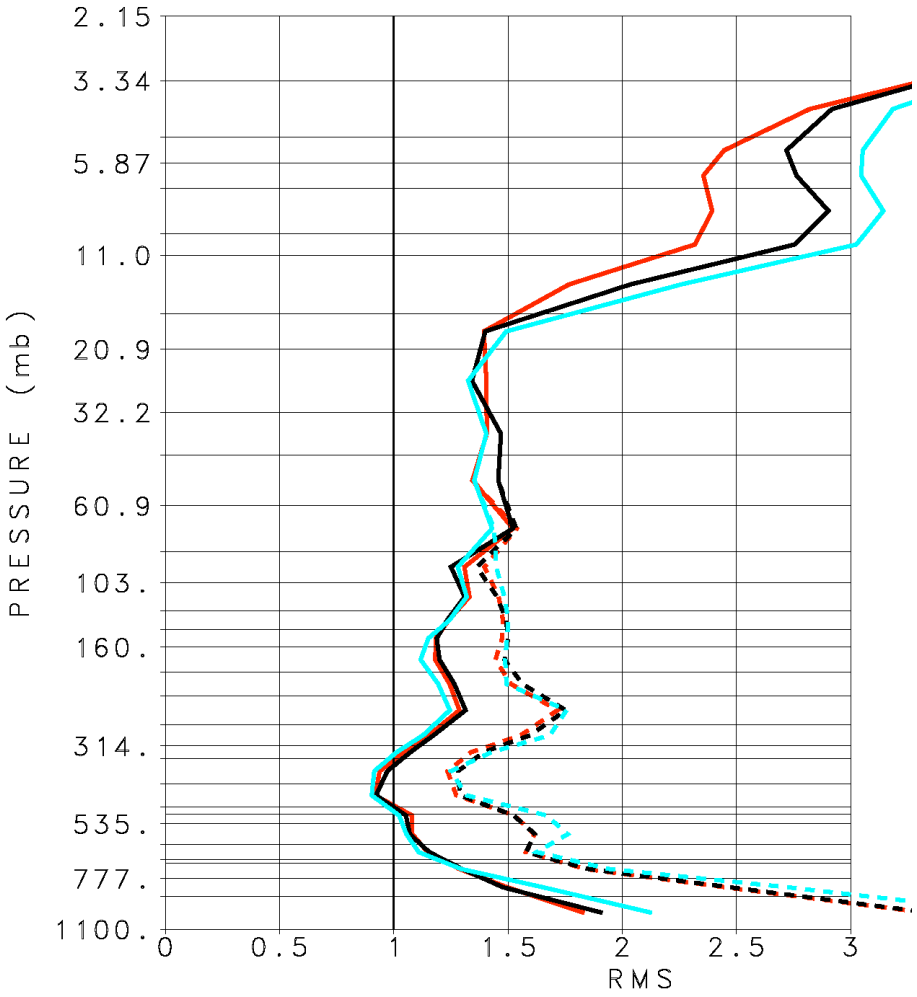
Candidate v5.0
Candidate v5.0 Stratosphere Good Cases

LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003
50N to 50S Non-Ocean



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Candidate v5.0
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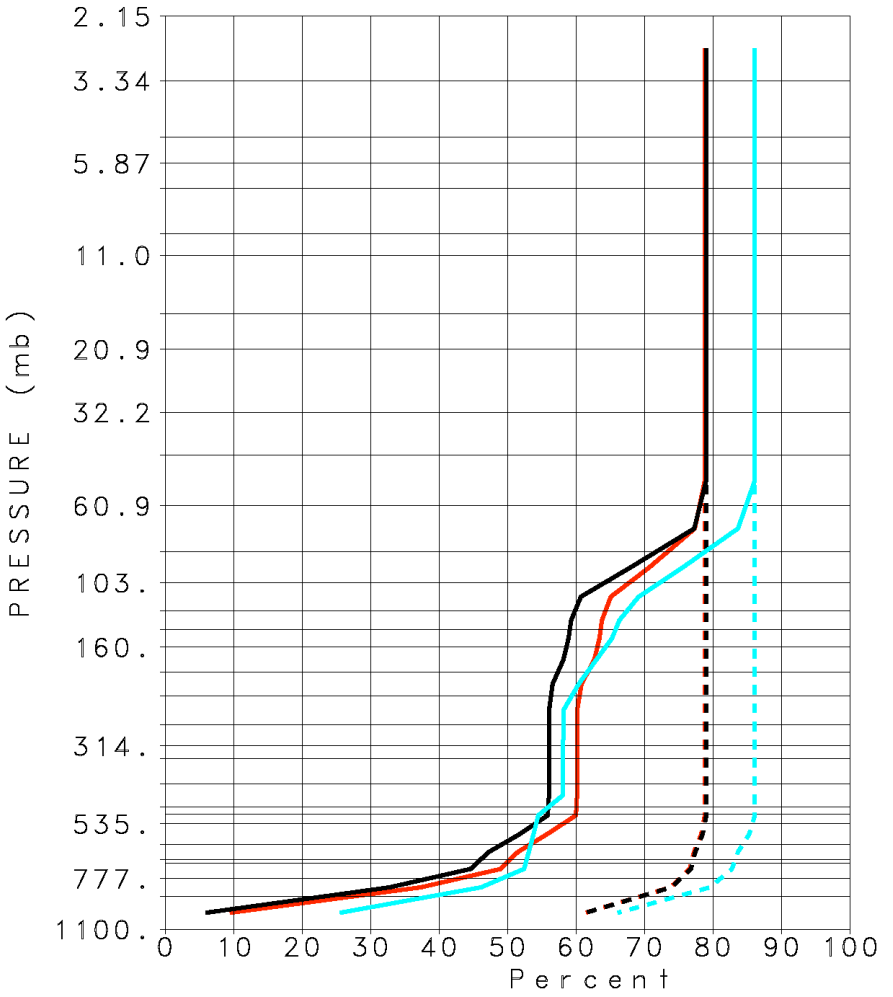
Percent of IR/MW Cases Included

January 25, 2003
50N to 50S Non-Ocean



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Candidate v5.0
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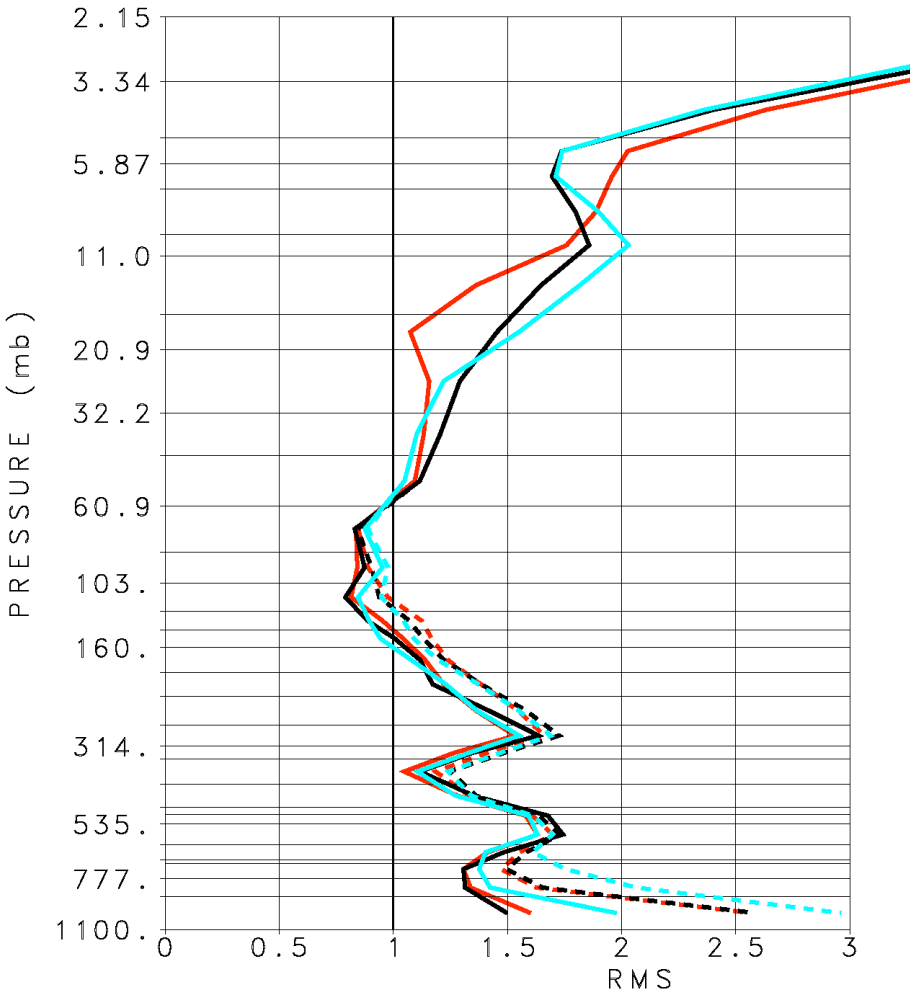
LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM "TRUTH"
January 25, 2003
Poleward of 50



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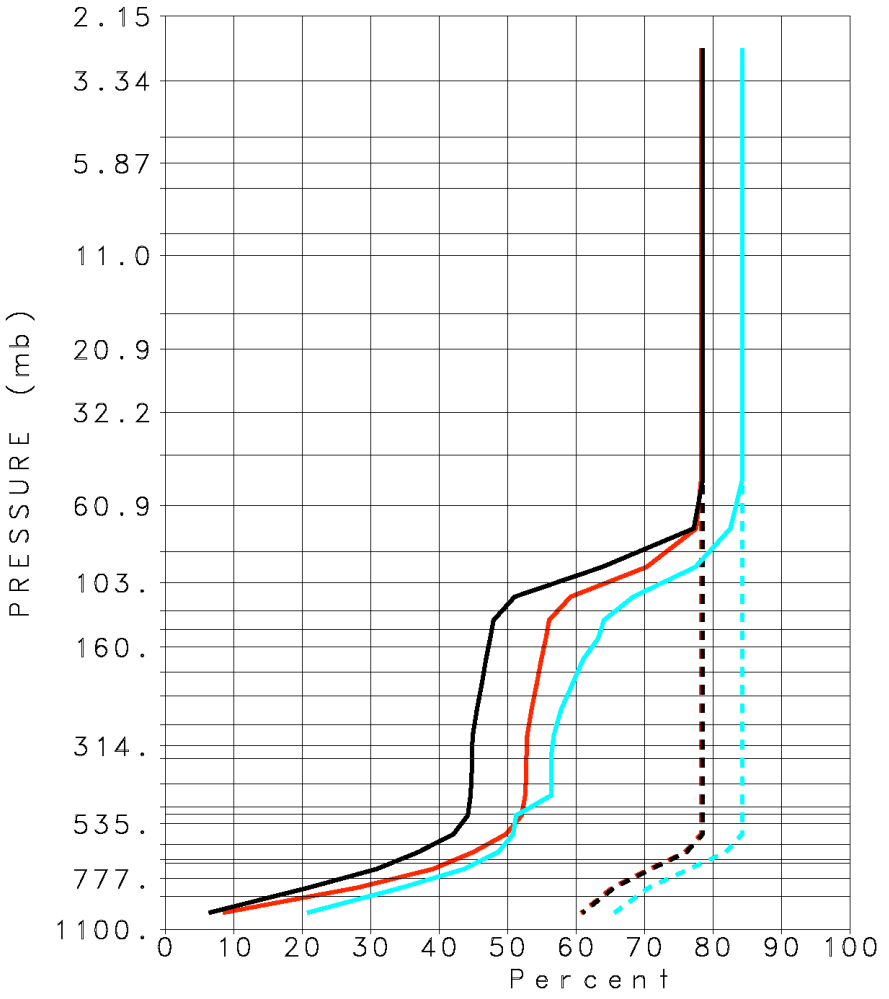
Percent of IR/MW Cases Included

January 25, 2003
Poleward of 50



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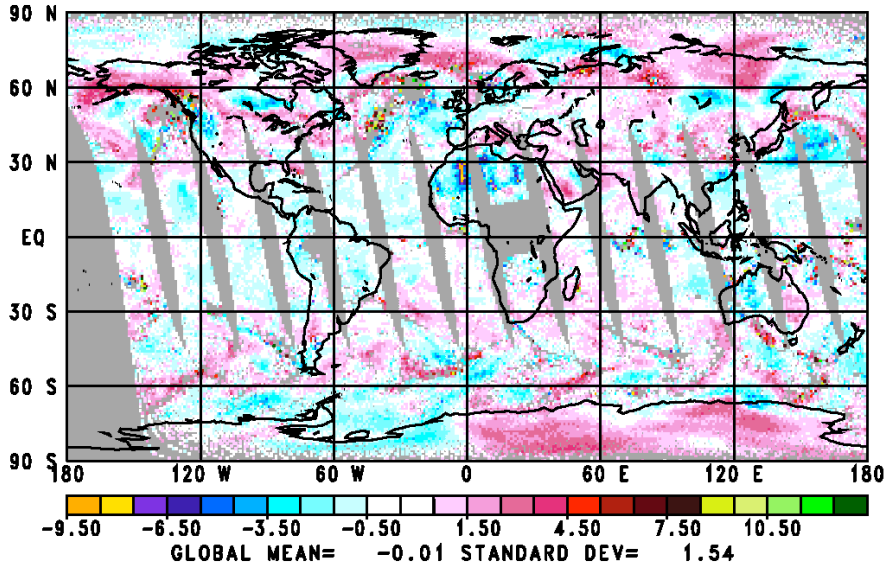
V4.9 with v4.7 Error Estimate Strat Good Cases
Candidate v5.0
Candidate v5.0 Stratosphere Good Cases

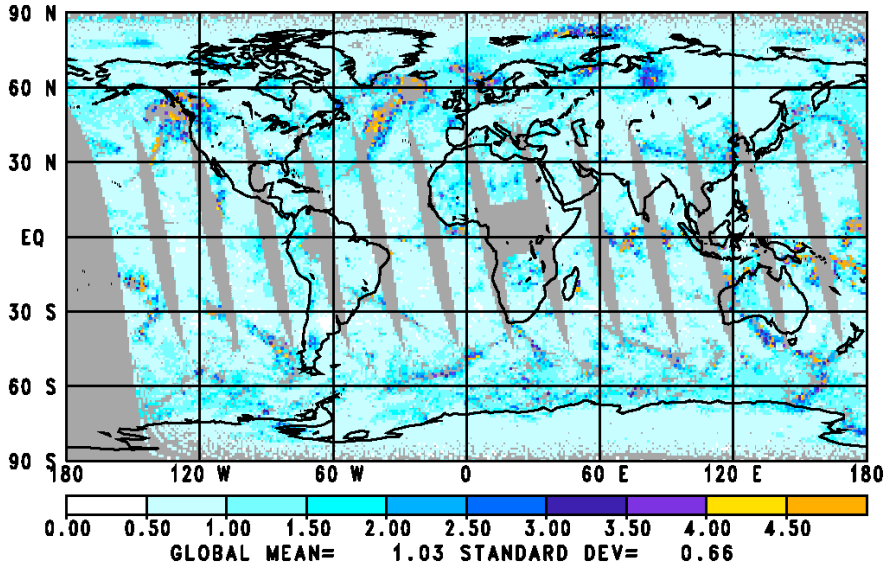
300 mb Temperature (K)
Retrieved minus ECMWF
January 25, 2003 Candidate version 5.0

300 mb Temperature Errors



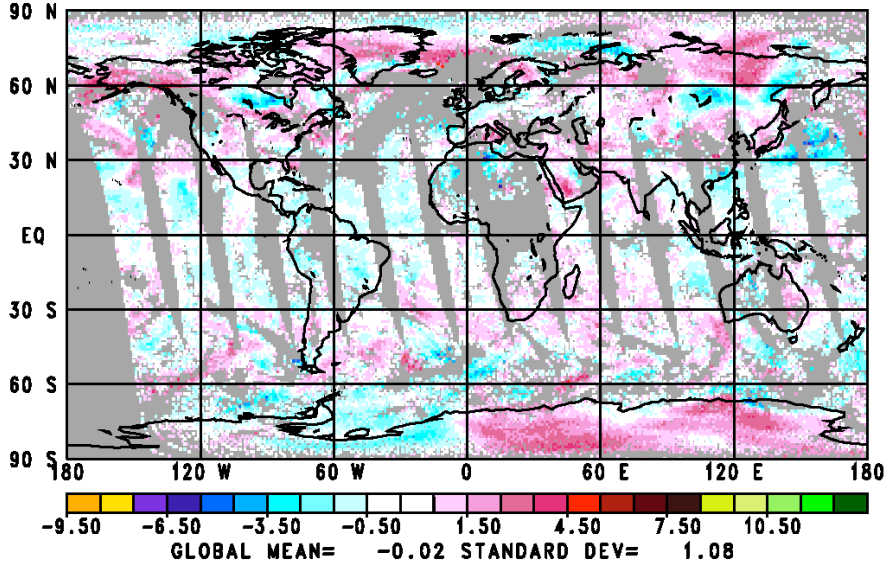
GLOBAL MEAN= -0.01 STANDARD DEV= 1.54

300 mb Temperature Predicted Errors



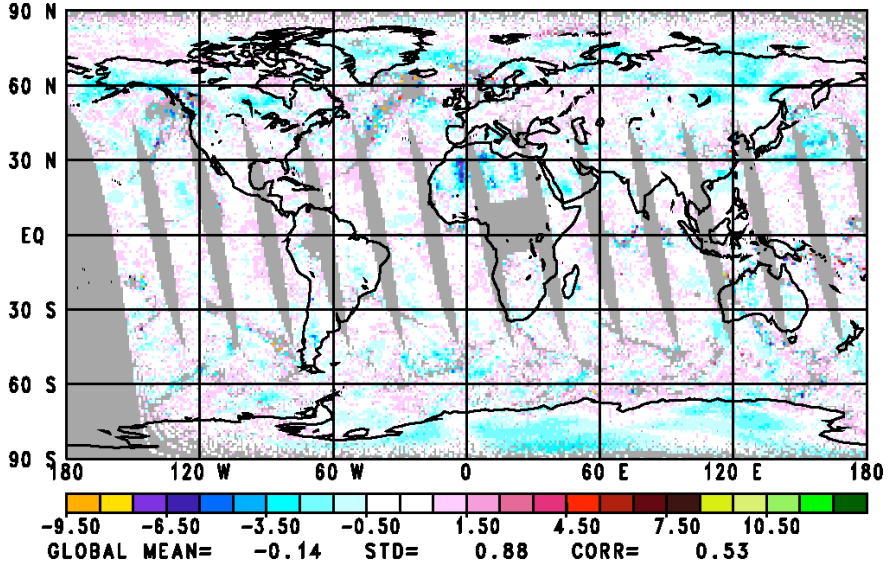
GLOBAL MEAN= 1.03 STANDARD DEV= 0.66

Error when P_{good} ge 300 mb



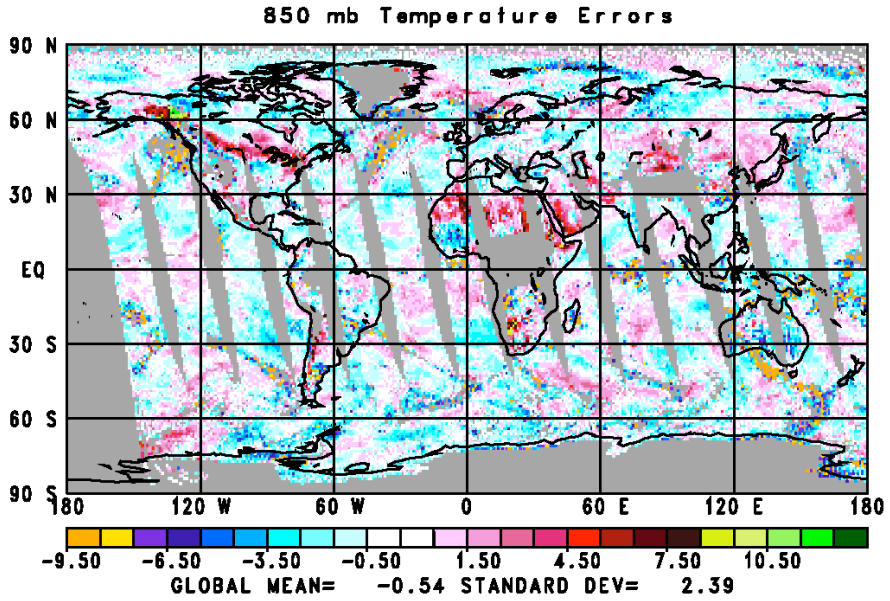
GLOBAL MEAN= -0.02 STANDARD DEV= 1.08

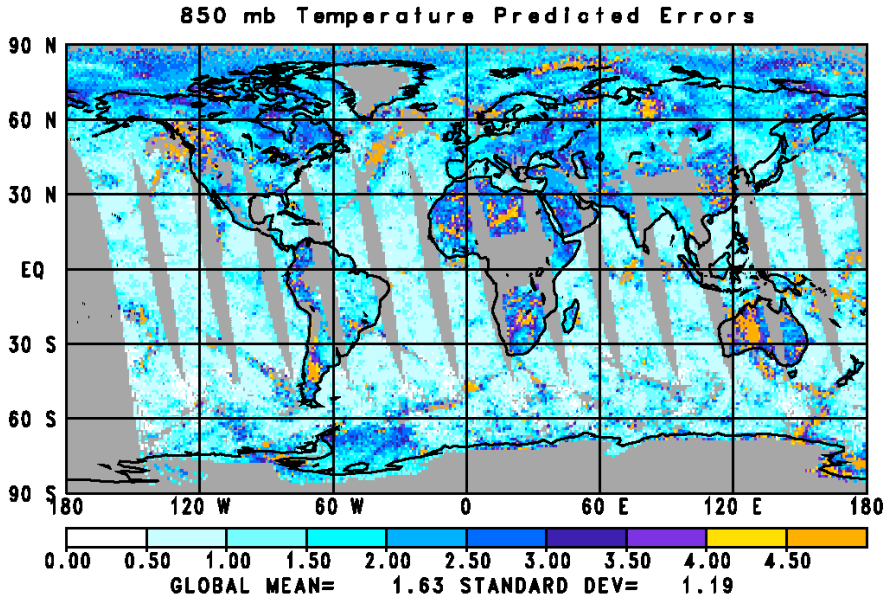
Predicted Error minus Absolute Value Error

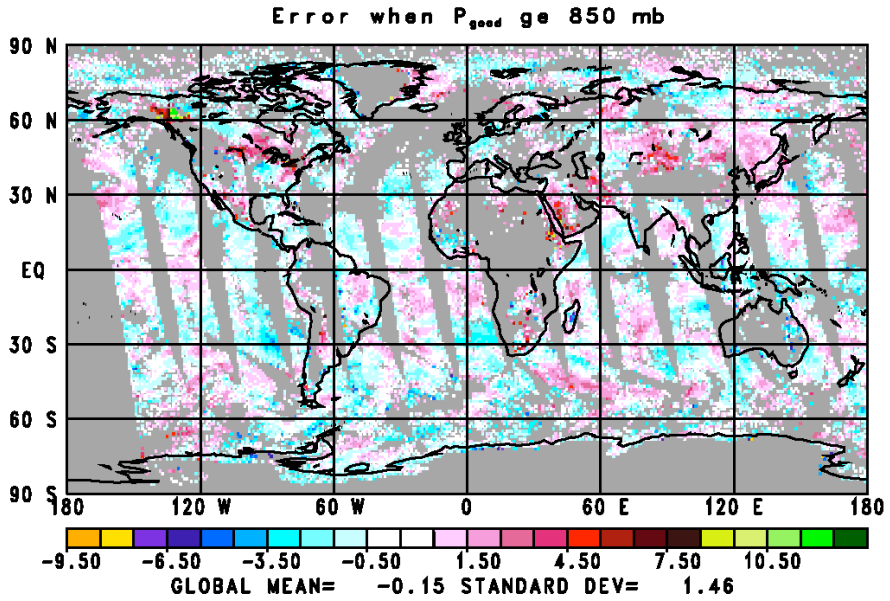


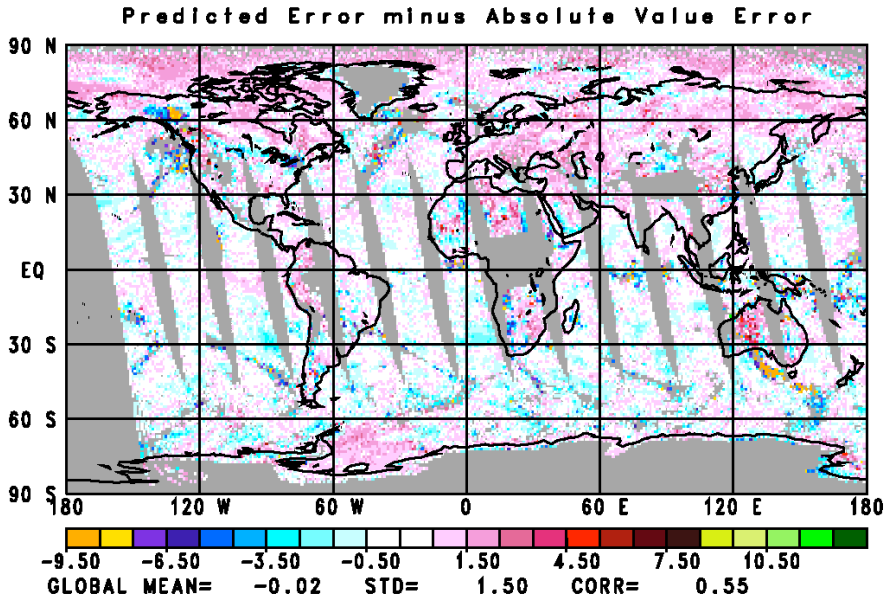
GLOBAL MEAN= -0.14 STD= 0.88 CORR= 0.53

850 mb Temperature (K)
Retrieved minus ECMWF
January 25, 2003 Candidate version 5.0









METHODOLOGY USED FOR SST QUALITY FLAGS

Generate coefficients M_{ij} based all non-frozen ocean combined IR/MW retrievals

Gives first pass coefficients, first pass error estimates $\delta^1 SST$

Refine coefficients based on ensemble in which $\delta^1 SST <$ threshold

Gives second pass coefficients, second pass error estimates $\delta^2 SST$

Set $\delta SST' = \delta^2 SST$

Results shown use 1.5K for $\delta^1 SST$ threshold

$\delta SST'$ used for quality control and error estimate

Flag SST according to $\delta SST'$

Current thinking for SST flags

SST flag = 0 if $\delta SST' \leq 1.0$

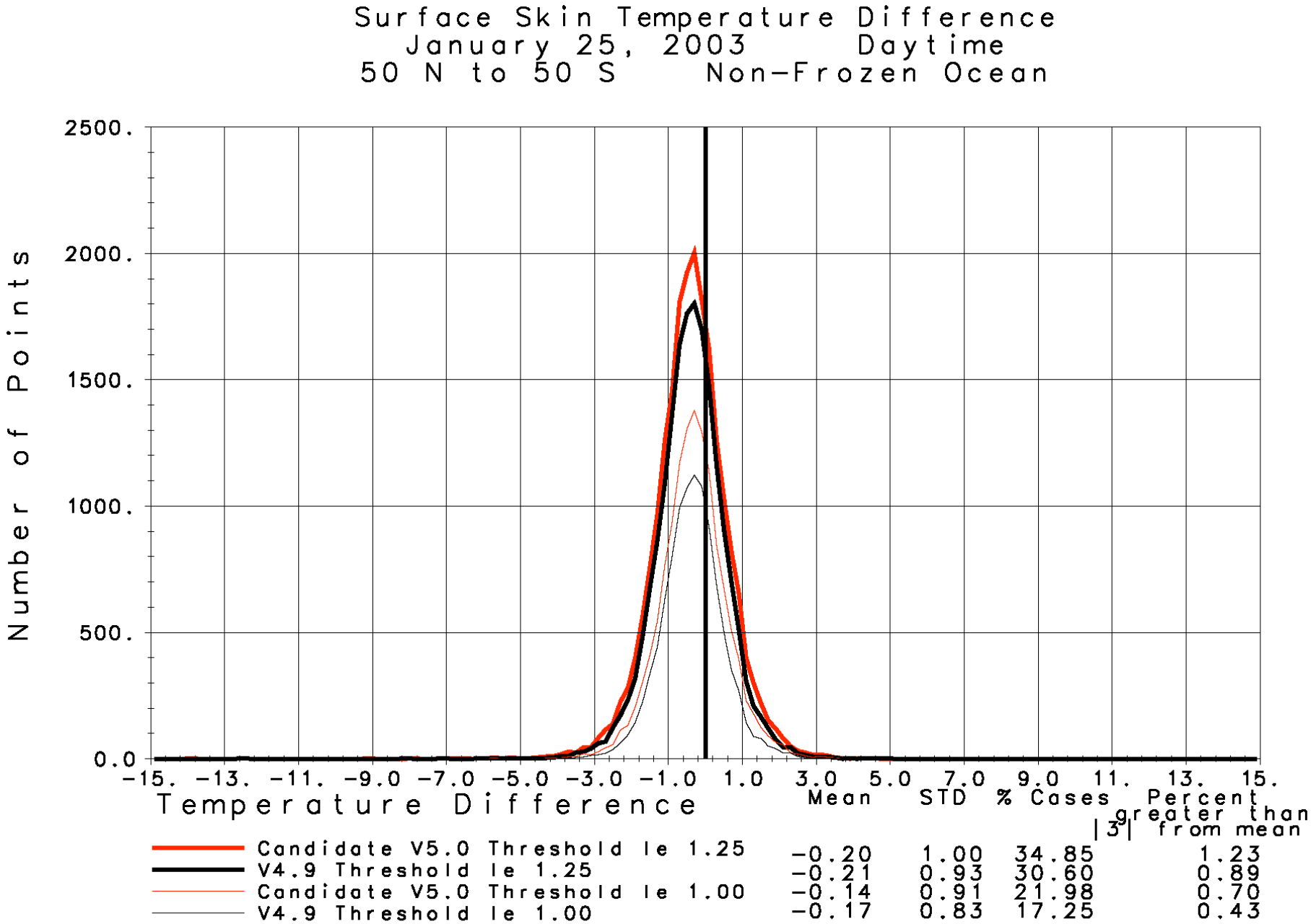
SST flag = 1 if $1 < \delta SST' \leq 1.25$

SST flag = 2 if $\delta SST' > 1.25$ (Do not use for level 3)

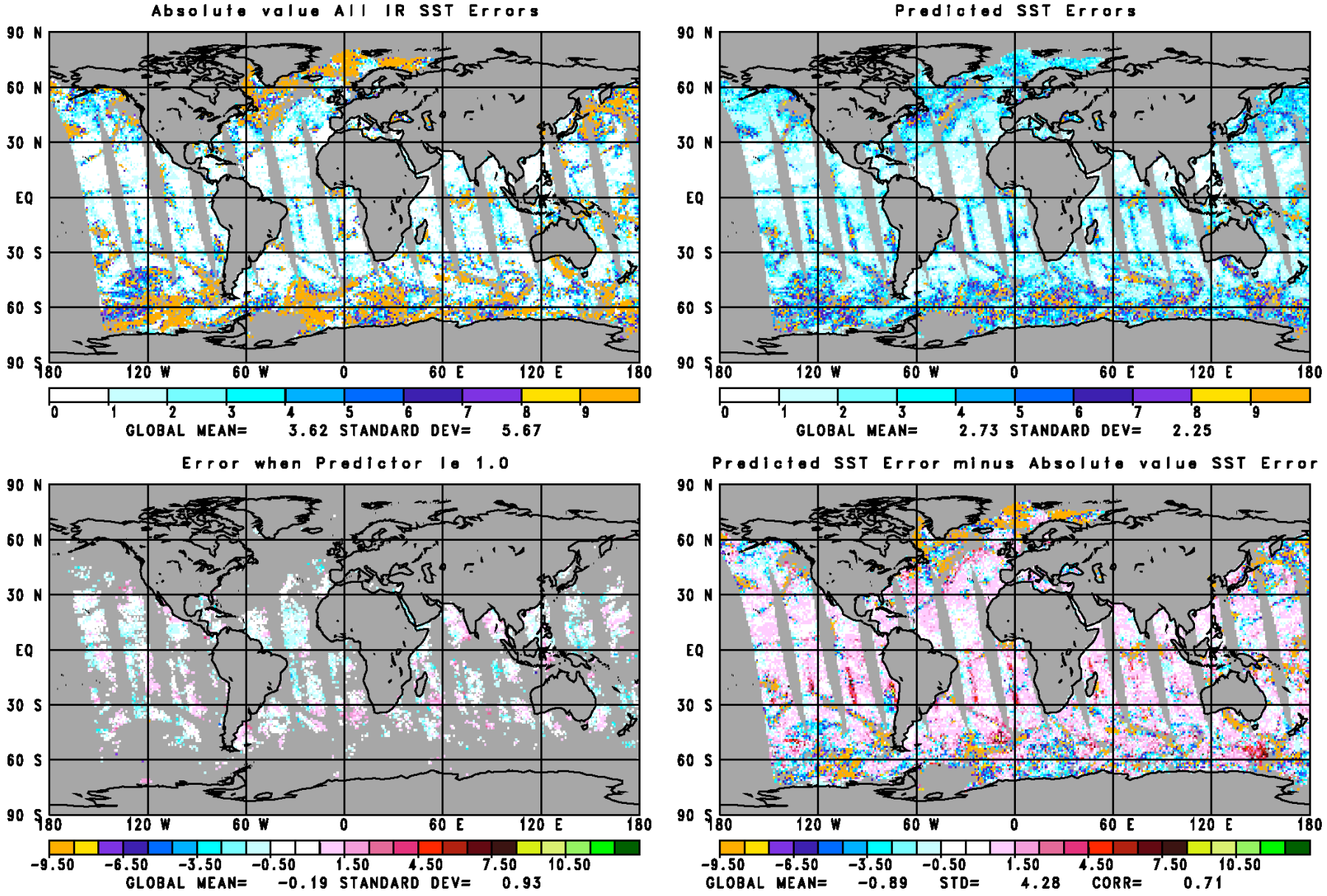
We have generated Version 4.7 monthly mean SST fields for January 2003, January 2004 2 ways

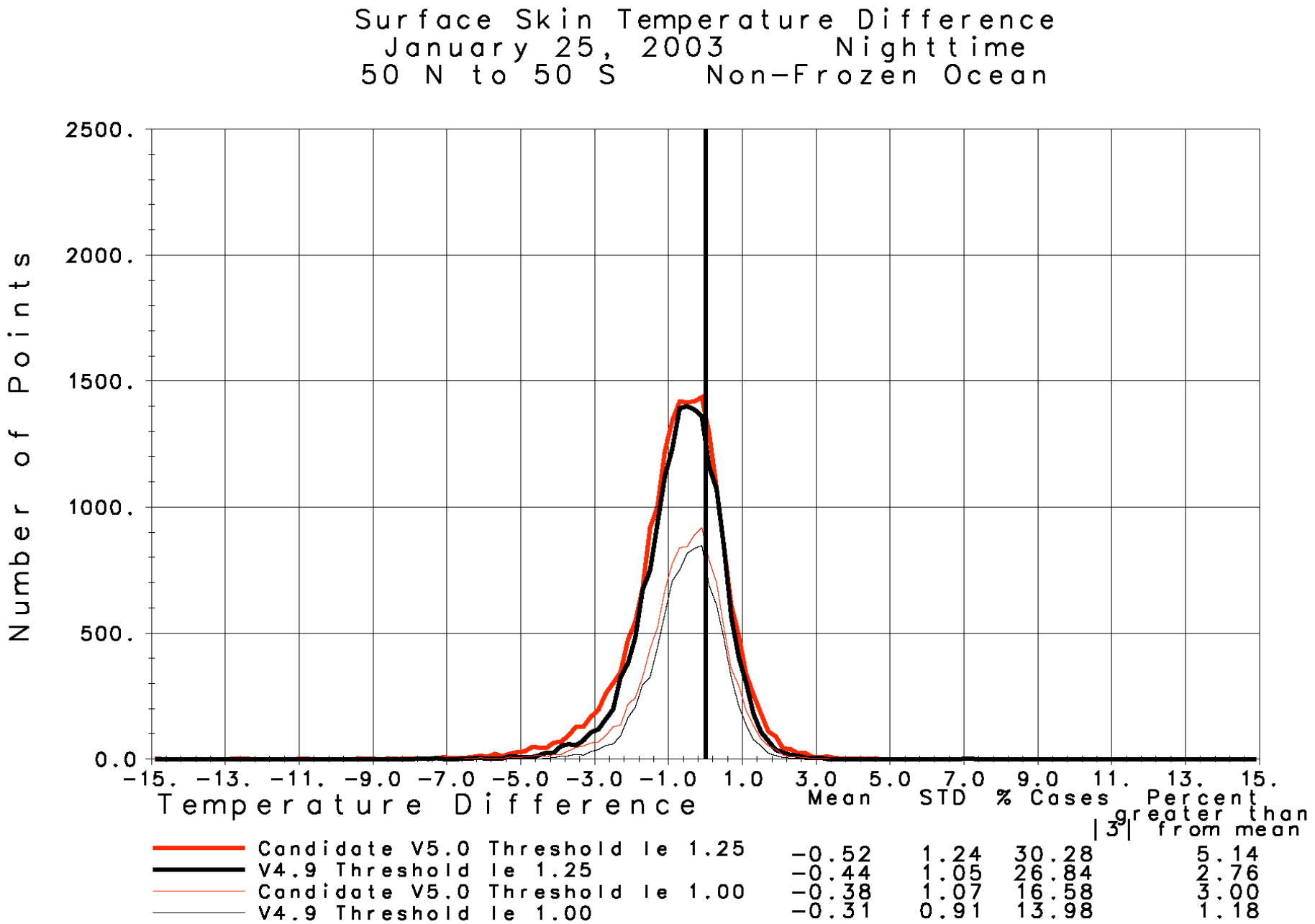
Including cases only for which $\delta SST' < 1.0$ and only for which $\delta SST' < 1.25$

We will assess coverage, accuracy of interannual monthly mean fields and differences

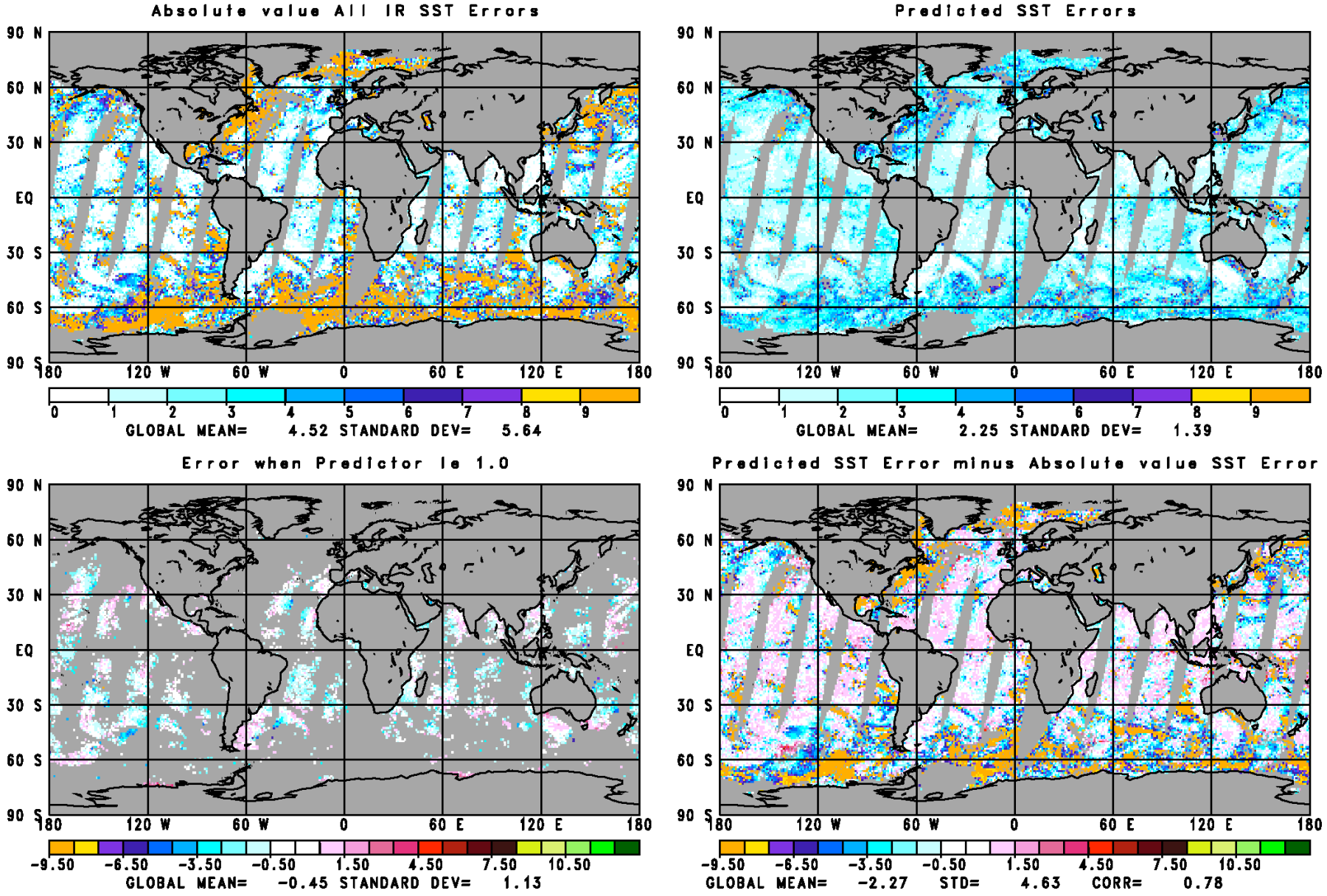

Surface Skin Temperature Difference
January 25, 2003 Daytime
50 N to 50 S Non-Frozen Ocean
Number of Points
2500.
2000.
1500.
1000.
500.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent
|3| greater than
from mean
Candidate V5.0 Threshold le 1.25 -0.20 1.00 34.85 1.23
V4.9 Threshold le 1.25 -0.21 0.93 30.60 0.89
Candidate V5.0 Threshold le 1.00 -0.14 0.91 21.98 0.70
V4.9 Threshold le 1.00 -0.17 0.83 17.25 0.43

Sea Surface Temperature (K)
Retrieved minus ECMWF
January 25, 2003 Candidate version 5.0



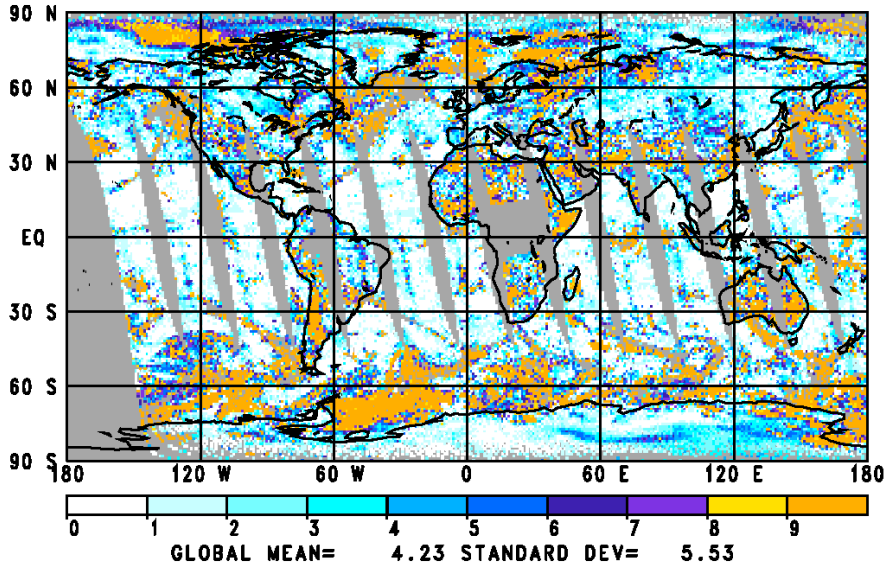

Surface Skin Temperature Difference
January 25, 2003 Nighttime
50 N to 50 S Non-Frozen Ocean
Number of Points
2500.
2000.
1500.
1000.
500.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent
|3| greater than from mean
Candidate V5.0 Threshold Ie 1.25 -0.52 1.24 30.28 5.14
V4.9 Threshold Ie 1.25 -0.44 1.05 26.84 2.76
Candidate V5.0 Threshold Ie 1.00 -0.38 1.07 16.58 3.00
V4.9 Threshold Ie 1.00 -0.31 0.91 13.98 1.18

Sea Surface Temperature (K)
Retrieved minus ECMWF
January 25, 2003 Candidate version 5.0



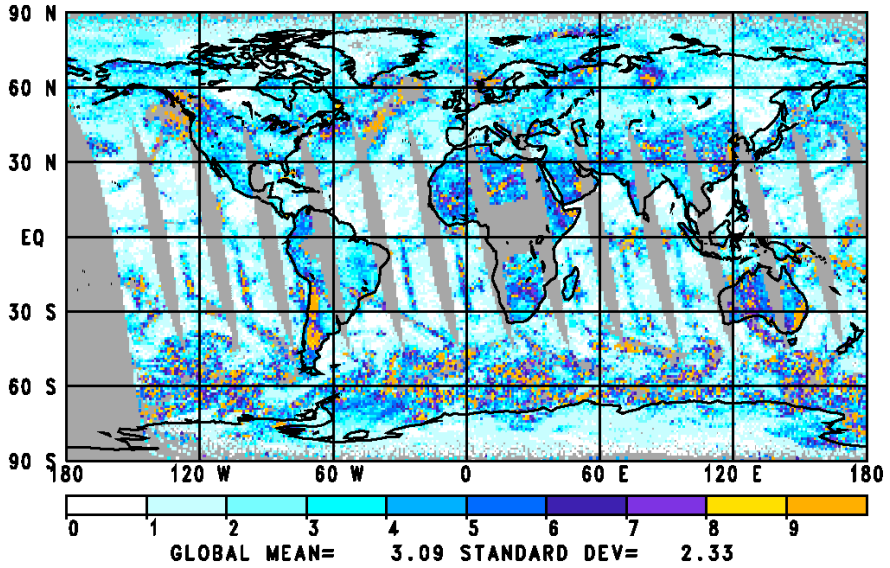
Surface Skin Temperature (K)
Retrieved minus ECMWF
January 25, 2003 Candidate version 5.0

Absolute value All IR SST Errors



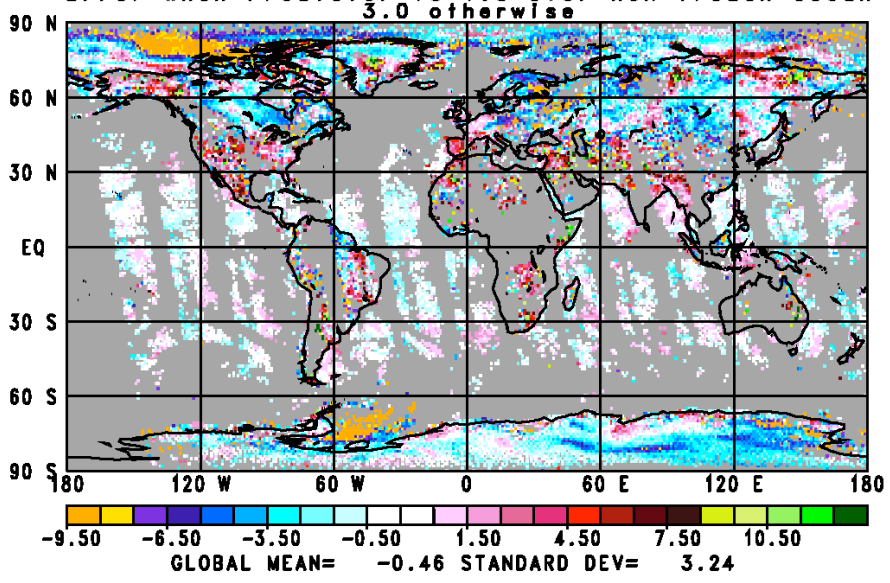
GLOBAL MEAN= 4.23 STANDARD DEV= 5.53

Predicted SST Errors



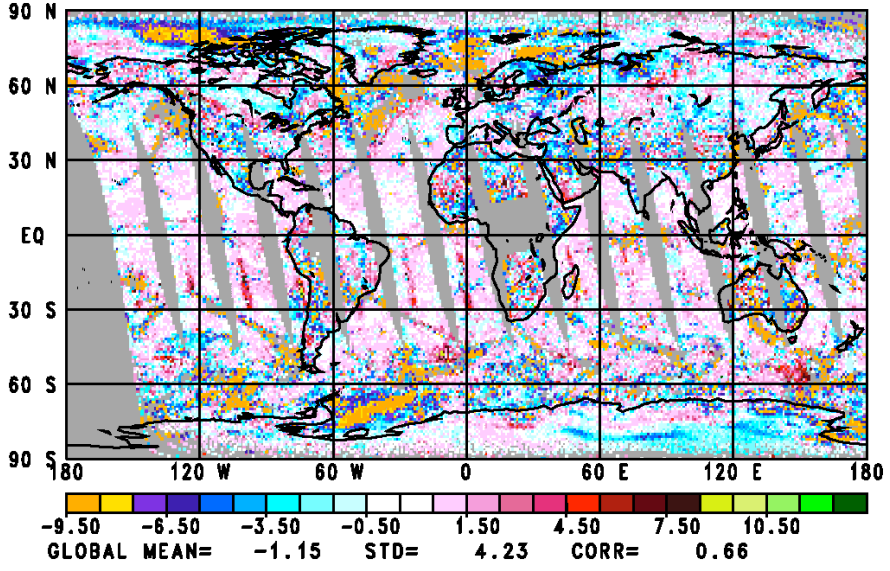
GLOBAL MEAN= 3.09 STANDARD DEV= 2.33

Error when Predictor Ie 1.0 over non-frozen ocean
3.0 otherwise



GLOBAL MEAN= -0.46 STANDARD DEV= 3.24

Predicted SST Error minus Absolute value SST Error



GLOBAL MEAN= -1.15 STD= 4.23 CORR= 0.66

EMPIRICAL ERROR ESTIMATES FOR $\hat{R}_i$

Error in $\hat{R}_i$ has two components arising from 1) random noise and 2) errors in η

Random noise component is given by $NE\Delta N_i$ times A

A is noise amplification factor

Calculation is done in brightness temperature domain to give $\delta\hat{\Theta}_i'$

$$\delta\hat{R}_i' = \left(\frac{dB}{dT}\right)_{\hat{\Theta}_i} \delta\hat{\Theta}_i'$$

We could model

$$\delta\hat{\Theta}_i' = \left[A \times NE\Delta N_i\right]\left(\frac{dB_i}{dT}\right)^{-1}_{\hat{\Theta}_i} + \sum_{1}^{15} M_{ij} Y_j$$

$$= N_i + \sum_{1}^{15} M_{ij} Y_j$$

where Y_j is the same as before

M would be a very big matrix

We have found

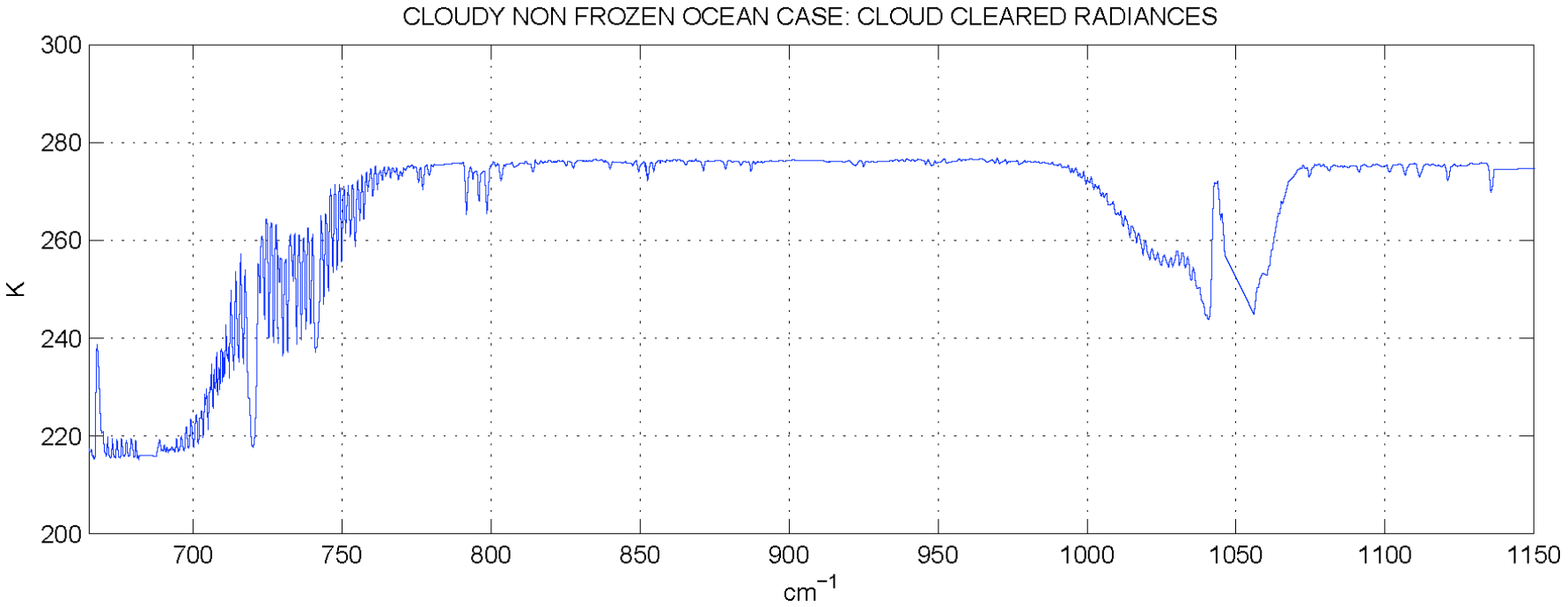
$$\delta\Theta_i' = N_i + \sum_{j=1}^{6} M_{ij}\delta T(p_j)'$$

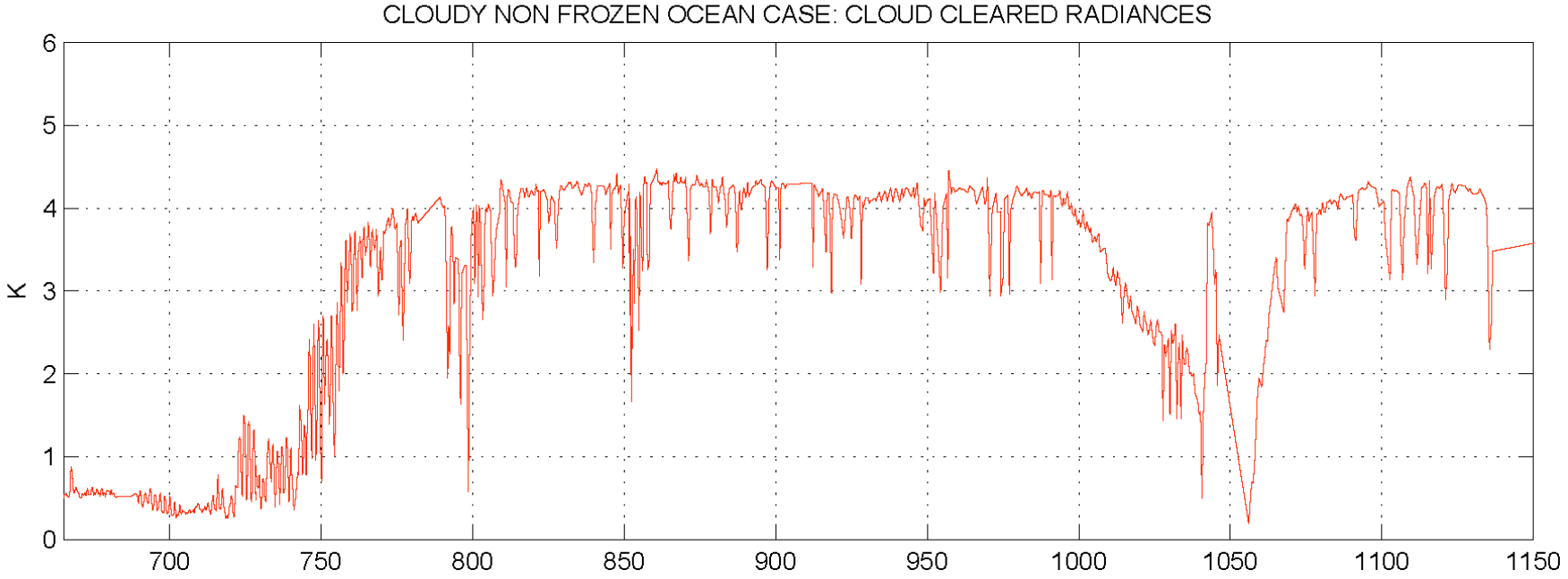
works as well

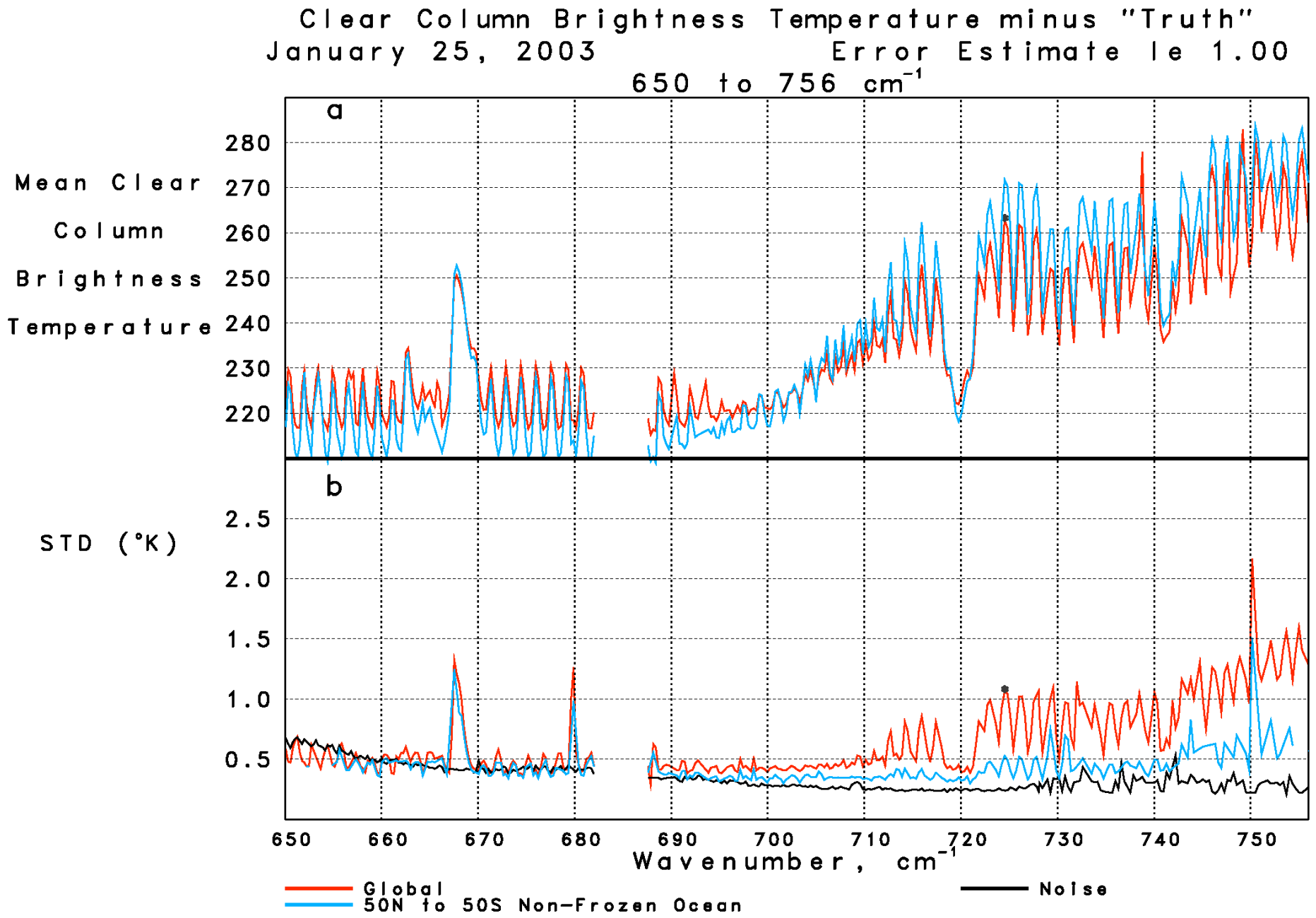
M is dimensioned 2386 x 6

We are looking into working in the radiance domain directly

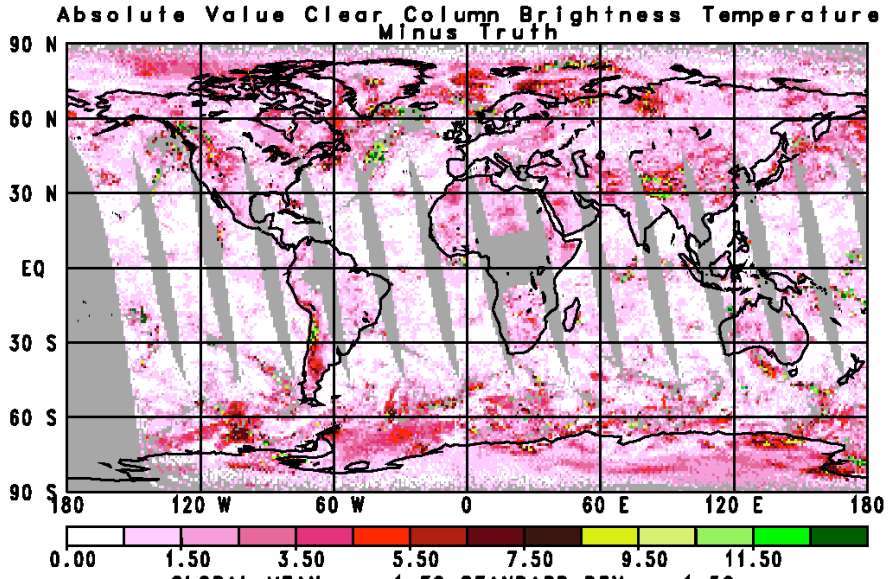
Dimension of M would not change

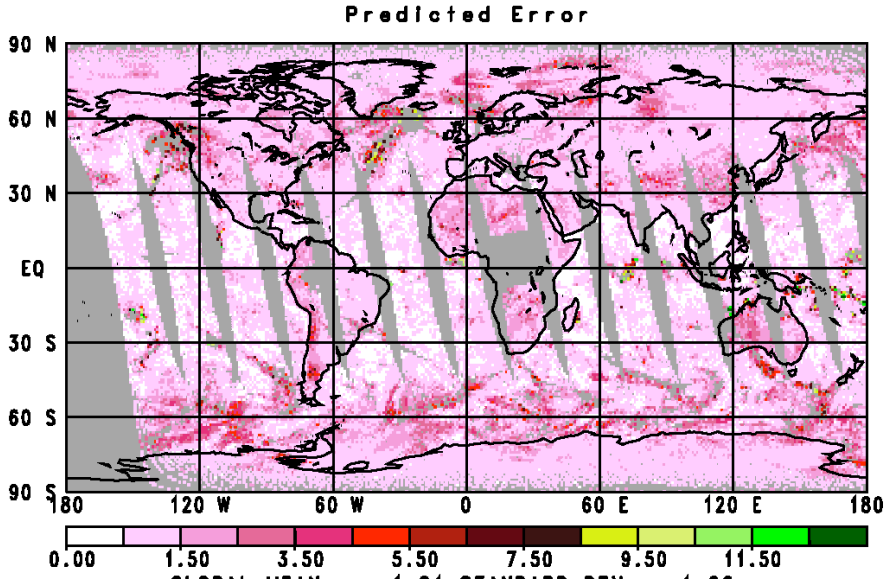

CLOUDY NON FROZEN OCEAN CASE: CLOUD CLEARED RADIANCES
300
280
260
240
220
200
K
700
750
800
850
900
950
1000
1050
1100
1150
cm−1

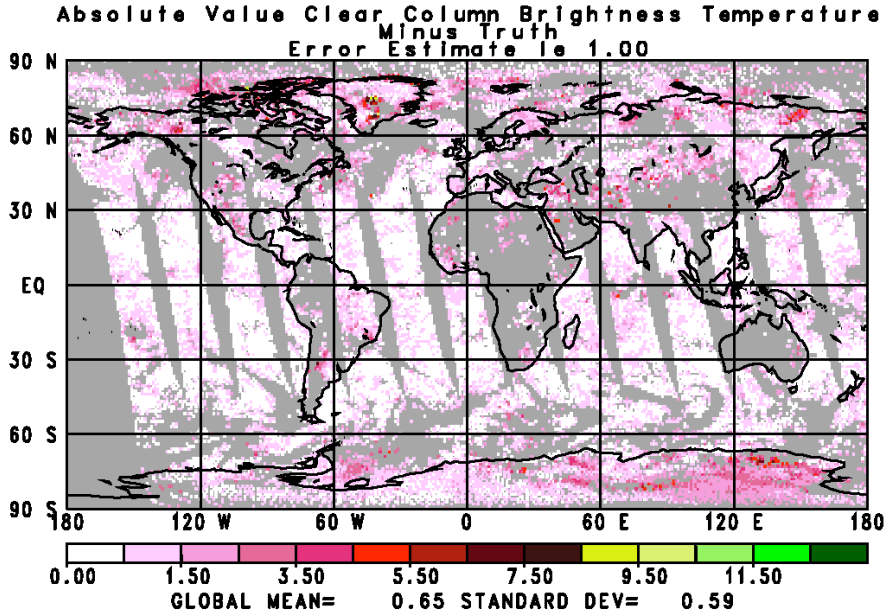

CLOUDY NON FROZEN OCEAN CASE: CLOUD CLEARED RADIANCES
6
5
4
3
2
1
0
K
700
750
800
850
900
950
1000
1050
1100
1150

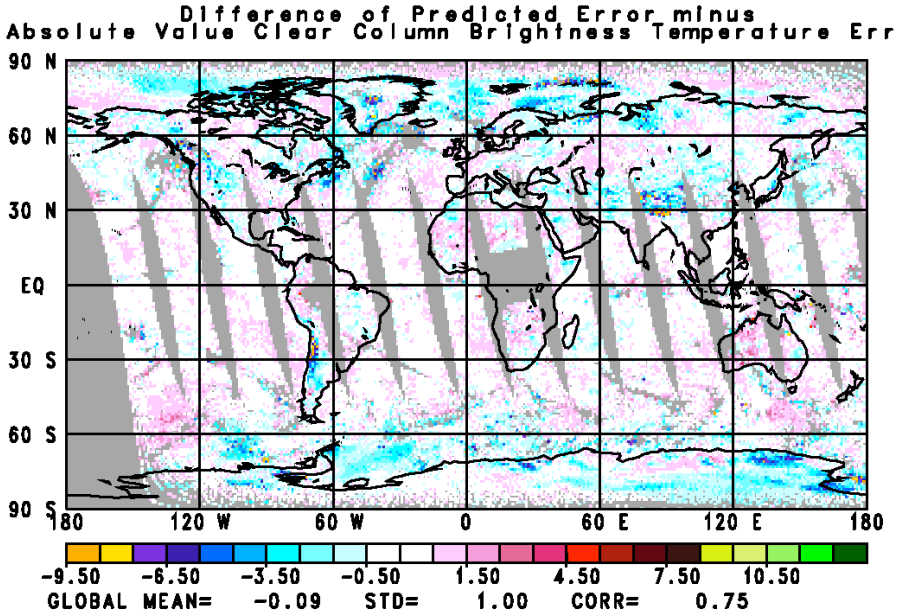

Clear Column Brightness Temperature minus "Truth"
January 25, 2003
Error Estimate Ie 1.00
650 to 756 cm-1
a
b
Mean Clear Column Brightness Temperature
STD (°K)
280
270
260
250
240
230
220
2.5
2.0
1.5
1.0
0.5
650
660
670
680
690
700
710
720
730
740
750
Wavenumber, cm-1
Global
50N to 50S Non-Frozen Ocean
Noise

Clear Column Brightness Temperature (K)
724.52 cm^{-1} Channel
January 25, 2003









MOISTURE PROFILE ERROR ESTIMATE $\delta q(p)'$

Error estimate is in the form of layer column density fractional error (100 layers)

Refers to fractional error in retrieval, not in truth

We have examined two approaches to determine coefficients M

$$\Delta X_i = \left(\frac{q_i - q_i^{TRUTH}}{q_i} \right) \text{ and } \Delta X_i = 2\left(\frac{q_i - q_i^{TRUTH}}{q_i + q_i^{TRUTH}} \right)$$

We use second approach which is more stable and allows for 200% error

Current methodology uses $\delta T(p)'$, analogous to what is done for $\delta \hat{R}_i'$

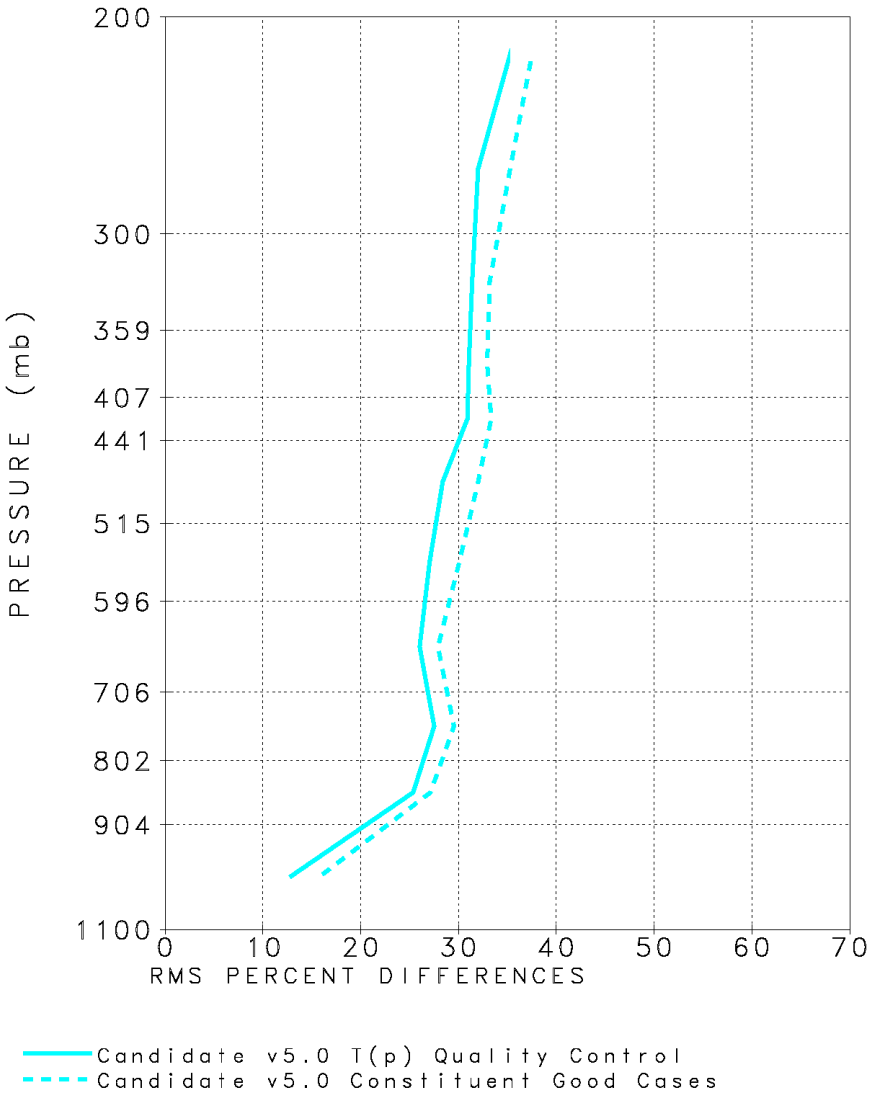
$$\delta q(p)' = \sum_{j=1}^{6} M_{ij} \delta T(p_j)'$$

M is dimensioned 100 x 6

M_{ij} found which minimizes $\text{RMS}\left[q_i \left(\Delta X_i - \delta X_i' \right) \right]$

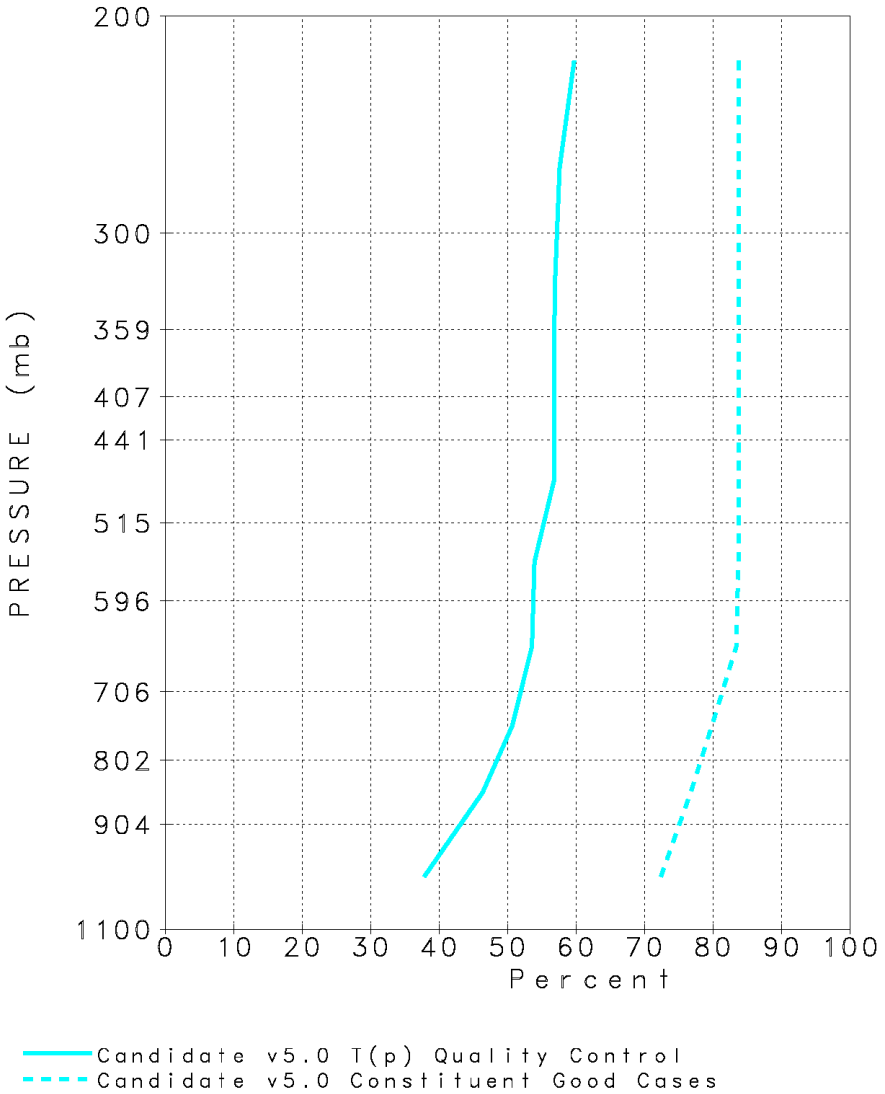
For data assimilation purposes, we recommend using q(p) for $p \leq p_{good}$

1 Km LAYER PRECIPITABLE WATER
% DIFFERENCES FROM "TRUTH"
January 25, 2003
Global



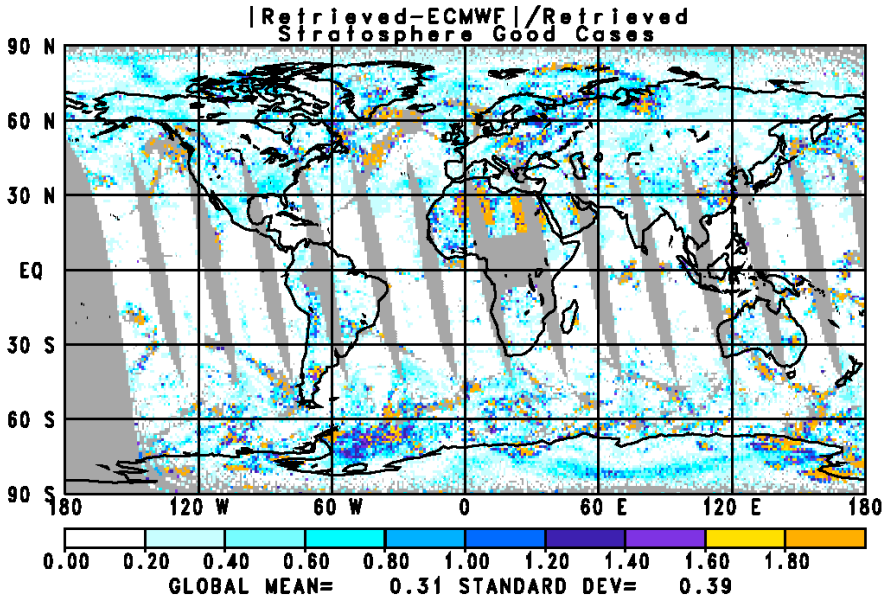
Candidate v5.0 T(p) Quality Control
Candidate v5.0 Constituent Good Cases

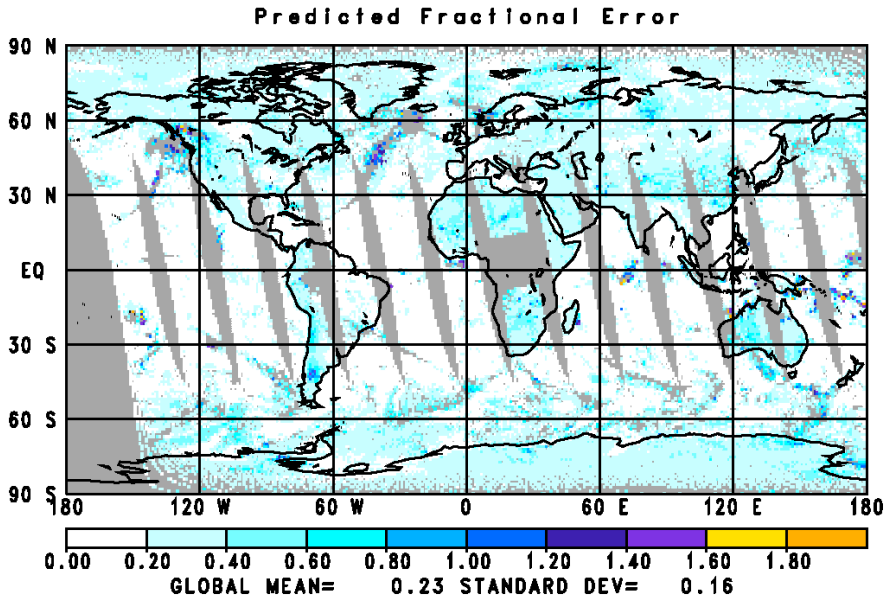
Percent Yield
Water
January 25, 2003
Global

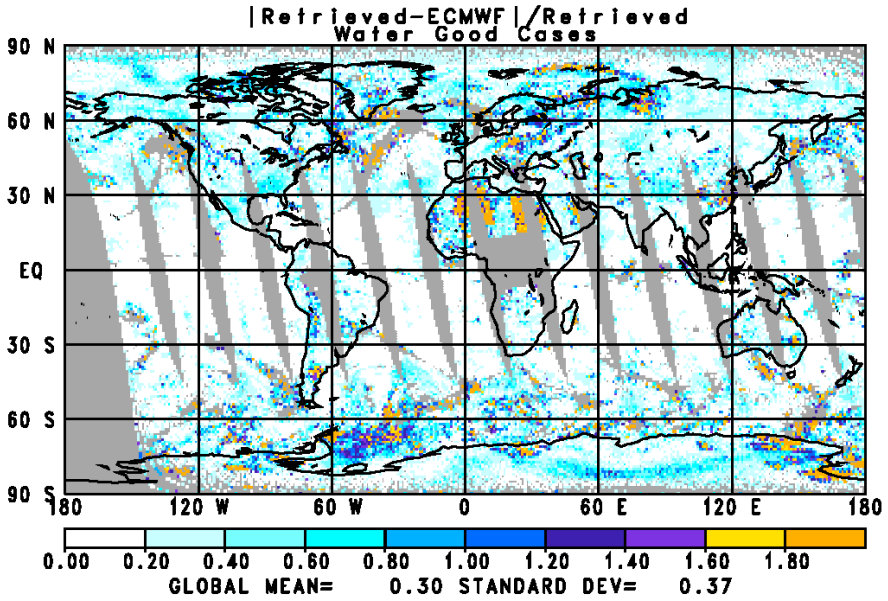


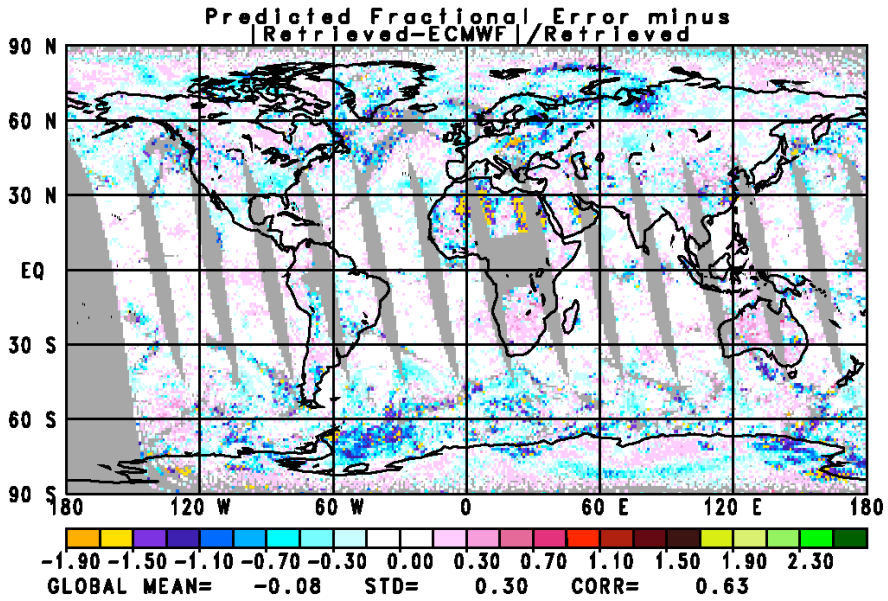
Candidate v5.0 T(p) Quality Control
Candidate v5.0 Constituent Good Cases

Layer Water Vapor Fractional Error
January 25, 2003 Candidate version 5.0
Surface

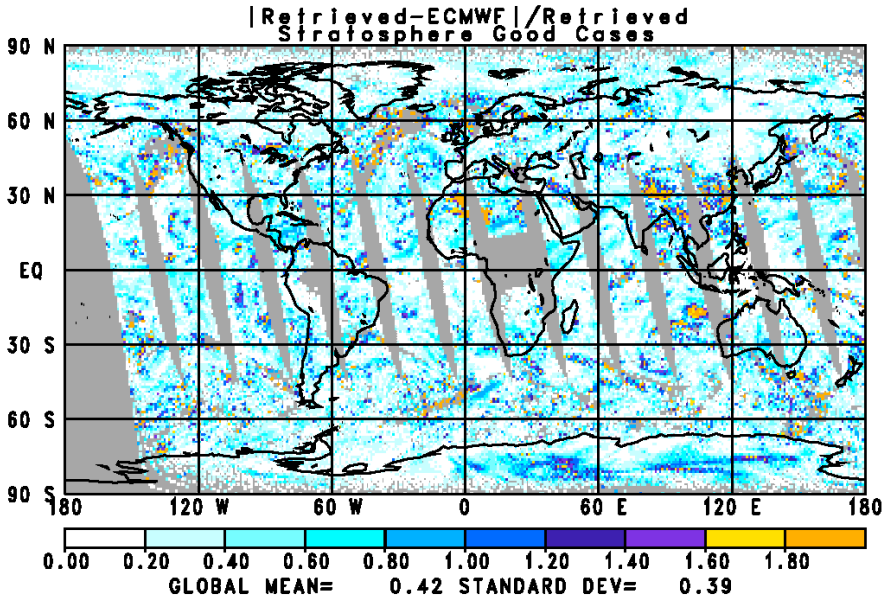


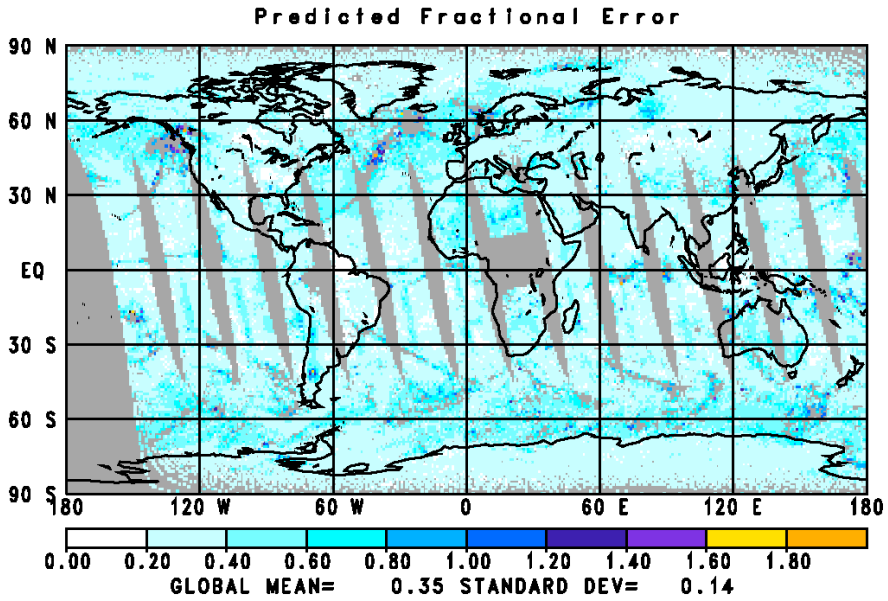


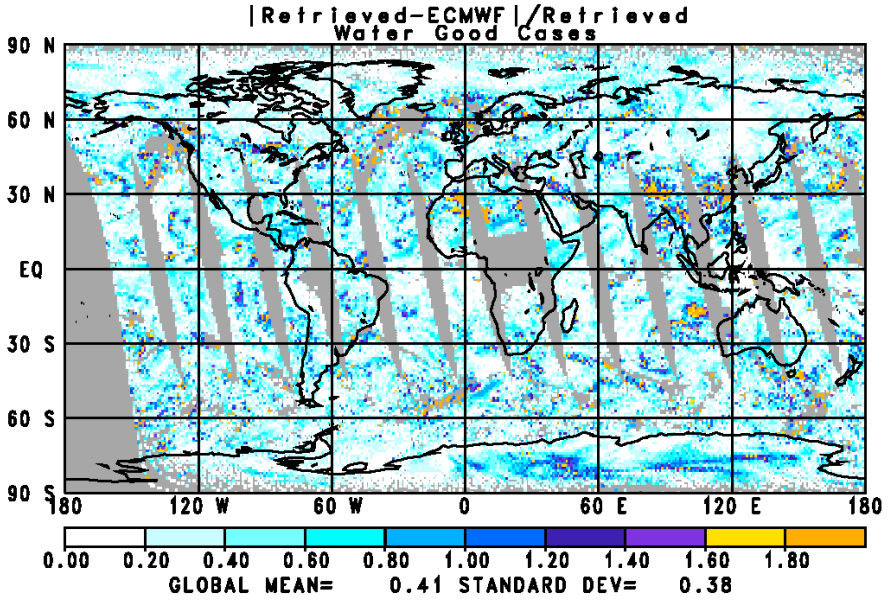


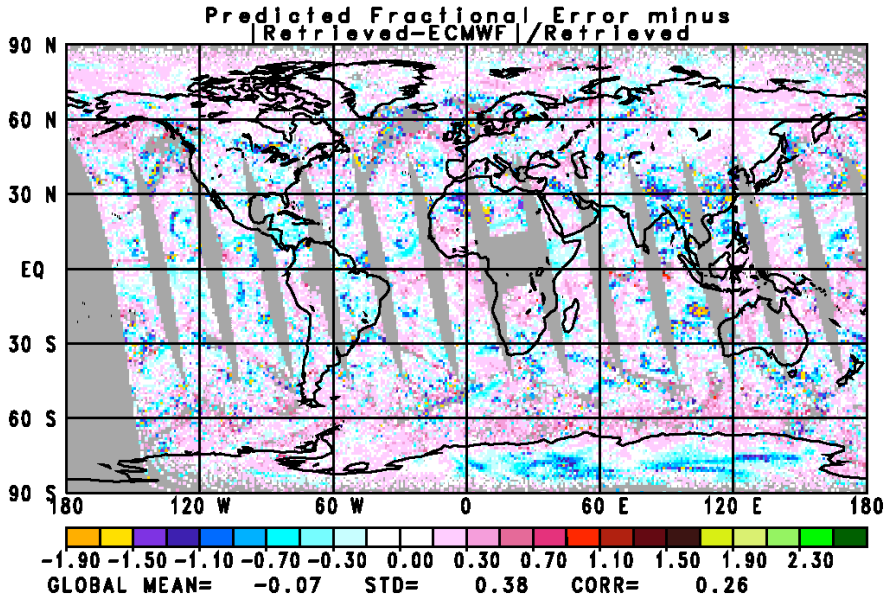


Layer Water Vapor Fractional Error
January 25, 2003 Candidate version 5.0
500 mb

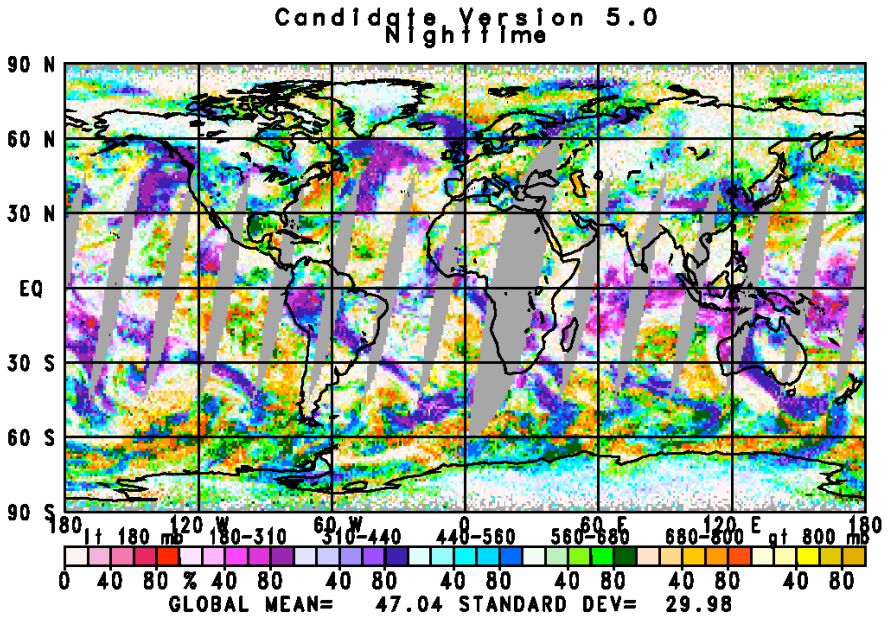


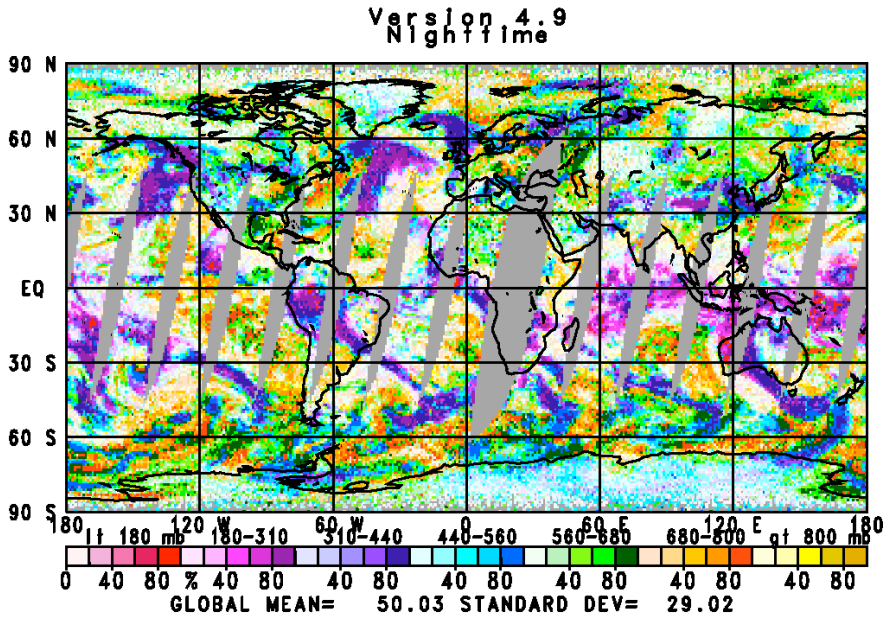


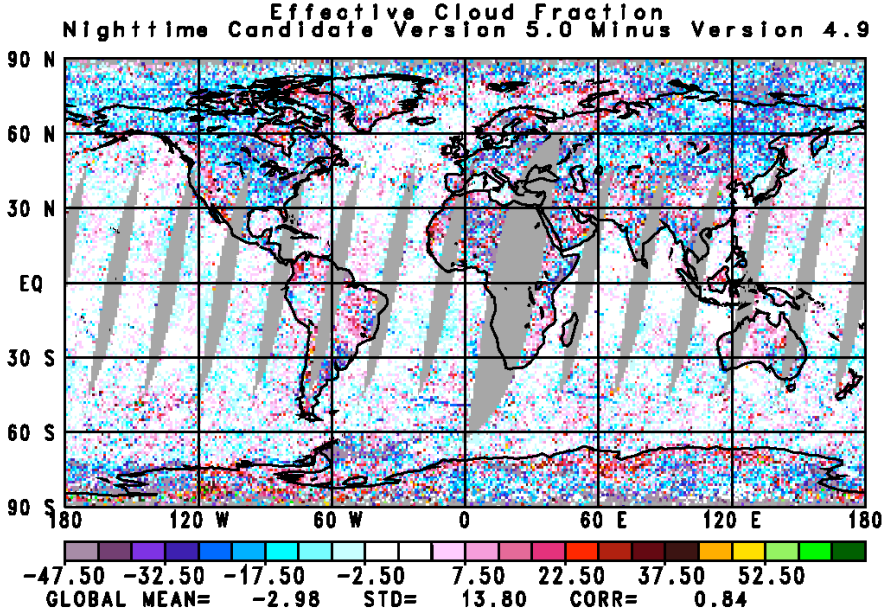


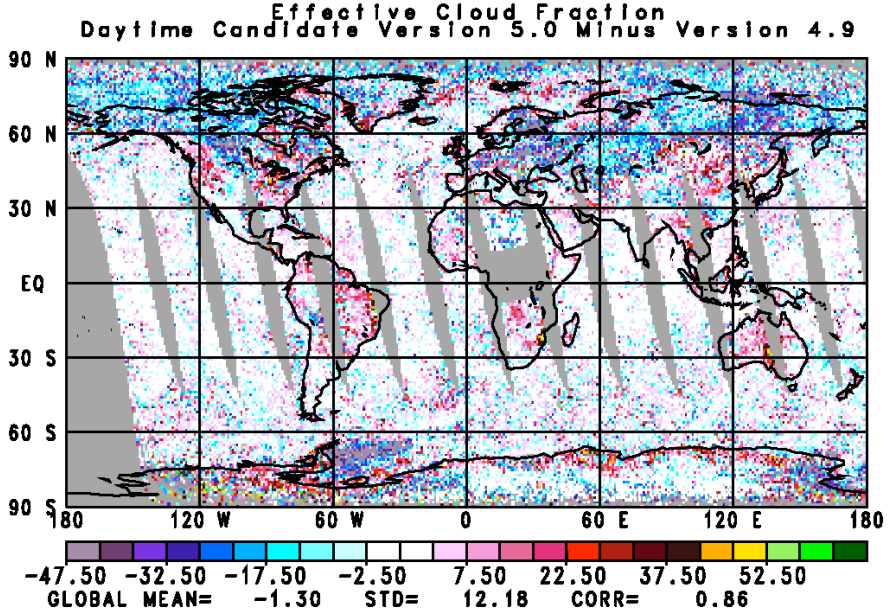


Cloud Parameters January 25, 2003









STATUS AND FUTURE WORK

Candidate Version 5.0

- Contains potentially significant improvements over current JPL version
  - Use of 4.2 μm non-LTE channels day and night
  - Use of less cloud clearing and cloud parameter retrieval channels over land
  - Also may contain different emissivity functions over land and ocean
- Needs further testing and optimization of namelist parameters
  - Should take about 2 weeks after AIRS Team meeting

Error estimates and quality control

- Needs further testing (14 or 15 terms?) and optimization
- Should take 1 additional week

Error estimates and quality control for AIRS only system

- Need to get AIRS only operational at GSFC
  - Should take 2 weeks after Science Team meeting
- Need to generate and test analogous methodology for error estimates and quality control
  - Does not use 3 of the 15 terms which involve AMSU observations
    - Use 11 or 12 terms
  - Should take 1-2 weeks after AIRS only system is operational at GSFC

GENERATION OF LEVEL 3 DATA (QUALITY FLAG 0 OR 1)

Approach used analogous to what was done in Version 4.0

Temperature profile

$p_{good} < 300$ mb (analogous to Version 4.0 stratosphere good)

Use T(p) down to p_{good}

$p_{good} \geq 300$ mb (analogous to Version 4.0 mid-troposphere good)

Use T(p) at all levels

Could use this test for $p < 300$ mb as well

Same cases included for all T(p)

Surface parameters

Non-frozen ocean

Uses cases where $\delta SST' < 1.25K$

"Land"

Use cases where $p_{good} \geq 300$ mb

Water vapor

Use cases passing Version 4.0 constituent good test

O_3, CO, CH_4

Use cases in which $p_{good} \geq 300$ mb

Clouds, OLR

Use all cases in which clouds can be determined